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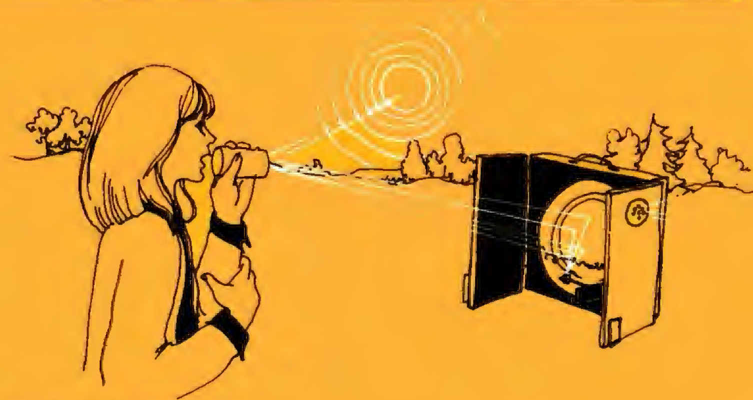
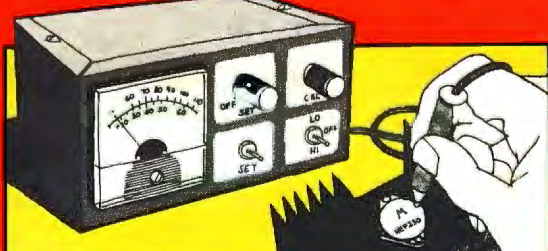
Light-Beam Communication Experiments



IT STARTED WITH ALEXANDER GRAHAM BELL

$15 Temperature Meter

DO YOUR TRANSISTORS RUN TOO HOT?



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CIRCLE NO. 13 ON FREE INFORMATION CARD

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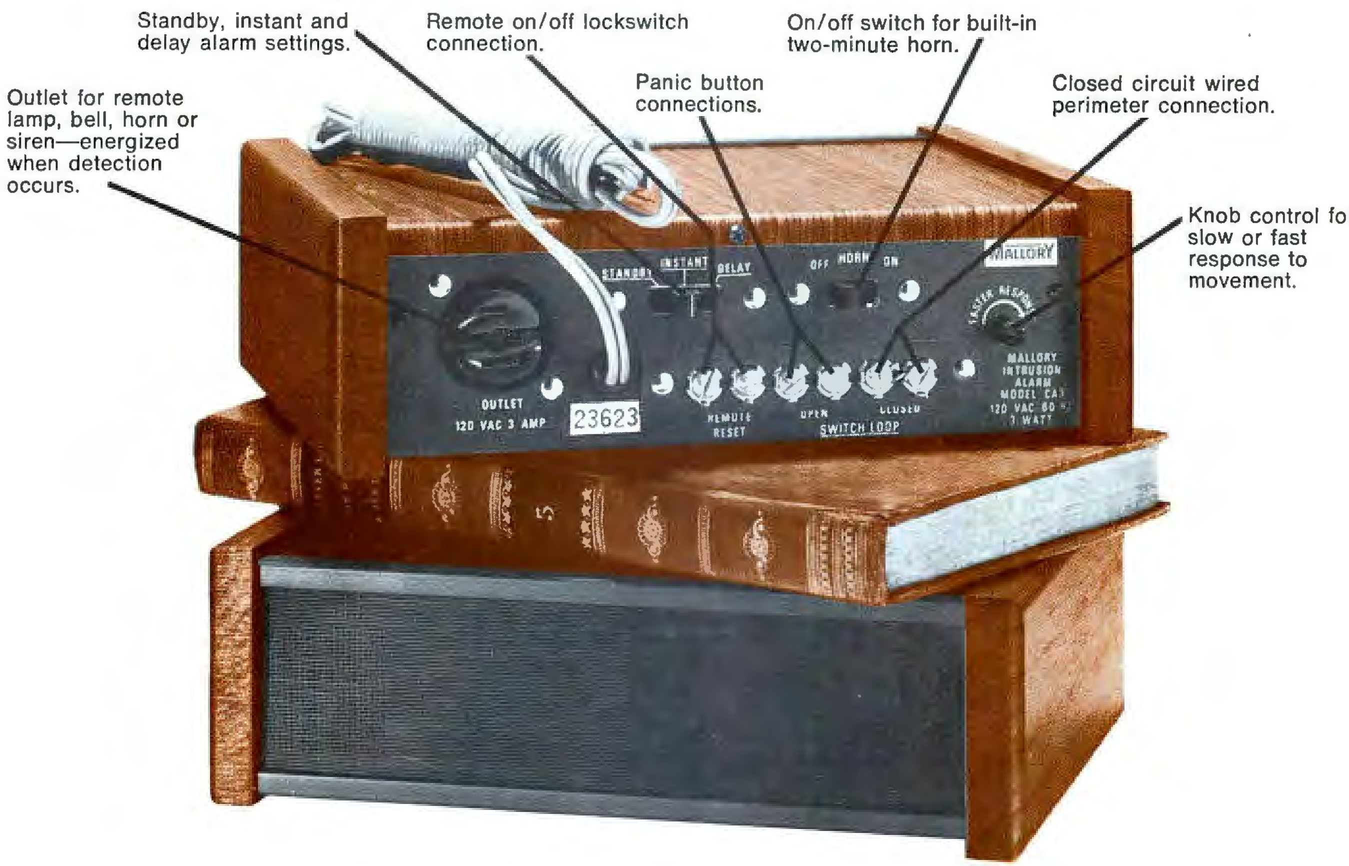

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TO: JOE RIDGE
WINEGARD SALES MANAGER

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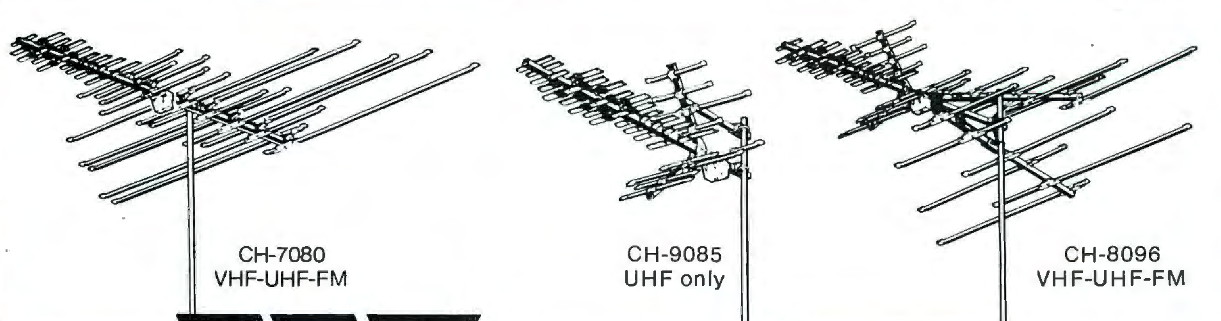

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FEBRUARY 1976 VOLUME 9, NUMBER 2

Popular Electronics®

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FEATURE ARTICLES

CONSTRUCTION ARTICLES

COLUMNS

PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

GOOD NEWS FOR MAIL-ORDER BUYERS

I have recently observed a growing number of complaints about mail-order purchases—some of them legitimate, some not. Most of them are concerned with shipping delays, with the seller neither acknowledging an order nor notifying the purchaser that there would be a delay. Without doubt, these represent fair expressions of discontent when the buyer has waited perhaps eight weeks with no word from the seller.

Lamentably, some mail-order sellers do not follow good business practices in these matters. We have tried to exert pressure on behalf of complainants, meeting with reasonable success. In one case, a company president listened well and hired a person just to handle this type of correspondence. In other cases, however, the seller simply oiled the squeeky wheel—a shortsighted approach, of course. To be fair, though, *most* mail-order companies who advertise in PE provide service in four days to three weeks.

Now the government has stepped into the picture! The Federal Trade Commission has set down an amendment to commercial practice rules for Mail Order Merchandise, effective February 2, 1976. In essence, it says that if no shipment time is clearly and conspicuously indicated in a solicitation (such as an advertisement), shipment must be made within 30 days after receipt of a properly completed order. Furthermore, the seller must have a reasonable basis at the time of solicitation to expect that shipment *will* be made within 30 days (or alternate stated shipping date) of receipt of order.

One assumes, therefore, that (as an example) a legitimate reason for not meeting a shipping date would be the receipt of a larger number of orders than anticipated. In such cases, the seller must inform the buyer of a revised shipping date or that a date cannot be determined—for whatever reason. This must be done within a reasonable time after the seller first becomes aware of the delay. Moreover, the seller must offer the buyer an option either to consent to a shipping delay or to cancel his order and receive a prompt refund. If cancellation is not received on or before a revised shipping date (30 days or less delay), it is assumed that the buyer consented to the delay. If stated delay is more than 30 days or indefinite, the order will be automatically deemed cancelled if not shipped within 30 days or unless the seller receives a response within 30 days specifically consenting to the delay. When the delay is indefinite, the buyer has a continuing right to cancel prior to a shipment.

If a notice of further delay is issued, the same rules above apply, but the seller must send the buyer a business reply envelope or prepaid postage to exercise the new option.

Prompt refund, by the way, means a refund by first-class mail within seven days of receipt of such a request or within one billing cycle in the case of cancelling a renewed option. Part of the new rules does not apply to subscriptions (such as magazine sales ordered for serial delivery).

In the recent past, I haven't looked kindly upon many new government regulations. But I do feel that this is a welcome one. In any event, to speed fulfillment of an order by mail, buyers should use a money order or credit card. Sending a personal check sometimes causes the seller to wait weeks for the check to clear before shipping.

Art Salsberg

Letters

SETTING THE RECORD STRAIGHT

I read with interest Mr. Frye's article in June 1975 concerning the taming of static electricity. We market a static meter identical to the one pictured, along with a complete line of static neutralization equipment. CMI (mentioned in the article) was acquired by 3M Company more than a year ago.—*Robert J. Kunz, Sales & Marketing Manager, Industrial Nuclear Products, 3M Company, Saint Paul, Minn.*

THANKS FOR "HOW-TO" ARTICLES

Many thanks for "How to Design Your Own Power Supplies" (June 1975). This was one of the most lucid tutorial articles I have read on the subject. I would, however, like to suggest including the following circuit to provide a simple, inexpensive means of adjustable current limiting to any of the basic pass-transistor designs illustrated in the article.—*John Hanson, Denver, Colo.*

I enjoyed "A Simple Method for Biasing Transistors" (June 1975), particularly because I needed a simple method for biasing transistors without having to use lengthy calculations. One thing I wish to point out is that if we "assume that the bias current through *R1* and *R2* is 10% as much as the collector current" (step 5), the stability factor, S, which should be about 6 goes up to 10 or more. But if we assume the bias current as 20% of the collector current, the stability factor will remain about 7.

If you want higher stability and can tolerate a bit more current drain, 20% is a good figure; but where current drain must be negligible and stability is of only secondary importance, a 10% figure is best.—*Muhammad Bashir, Lahore, Pakistan.*

I appreciated the well-written article "How to Listen to Out-of-State AM Broadcasts" (April 1975). I recently moved to western North Carolina from Monmouth County, New Jersey and was amazed at the change in reception. Here, there are no really clear channels, since I can hear the 1- or 2-Hz beats of the carriers of both clear-channel assigned stations and small local stations. Fading is the rule. Our best reception is generally from Boston (WBZ) and stations in Pittsburgh and Philadelphia. When the weather is right, WWL from New Orleans is exceedingly strong.

Since it is apparent that weather plays an important role in radio reception, I recommend reading *The Weather for Radio* published by Taylor Instrument Companies (Rochester, N.Y.)—*Paul E. Griffith, Black Mountain, N.C.*

DON'T CHANGE THE EQUALIZATION

In "Matching Tape Decks to Magnetic Tape" (May 1975), I think that the last thing to recommend is to alter the playback equalization curve. This would change the tonal balance of all tapes previously recorded on other decks. Since playback equalization of most recorders follows, more or less, the standard NAB or CCIR curves, it is wise to keep it unchanged.

If the deck has correctly adjusted playback preamplifiers, some new bias and recording equalization settings can be sought out to suit the magnetic properties of a particular tape.

The success of the Dolby noise reduction system indicates that the first thing to aim for is a high signal-to-noise (S/N) ratio. Therefore, instead of considering the distortion and playback output curves versus the bias level, it would be more interesting to put together on the same diagram the curve of the noise and hiss level and give the playback output obtained from a 1000-Hz signal recorded at the maximum level that gives the percentage of distortion (say, 2%) one is prepared to accept.

The bias current can then be adjusted for

the greatest distance between the two curves, representing the best S/N obtainable with a specific tape on a given deck. The sensitivity of the VU meters can next be set to 0 dB for the corresponding 1000-Hz signal level that yields the maximum allowable THD. Only after the bias current has been set can the recording equalization be adjusted to give a correct frequency response at playback. This can be done by taking the overall record/playback curve at a safe recording level (e.g. −20 dB).

It cannot be overemphasized that the bias oscillator must be as clean as possible from the odd harmonics.—*J.P. Van Dormael, Temse, Belgium*

PRO'S AND CON'S OF METRICATION

The November 1975 editorial, titled "The Metrication Waiting Game," was certainly appropriate. Phono cartridges are an interesting case—tracking force in grams, stylus overhang in millimeters, reference velocity in cm/s . . . and a mounting center dimension of ½".

Because we deal in both English and metric units, we are interested in the metrication cause.—*Fred W. Nichols, Marketing Manager, Audio-Technica U.S., Inc., Fairlawn, Ohio*

The November 1975 Editorial states that "there is no serious move in our schools to teach upcoming generations the system of weights and measures that must ultimately be adopted." I don't know what your criterion of "serious" is, but when the metric system is taught and used in every chemistry, biology, and physics class I ever knew about or visited in the past 38 years of science teaching, I think that you must admit that there is a definite effort to teach a large segment of upcoming generations something about the metric system.—*Paul R. Doe, Hyde Park, N.Y.*

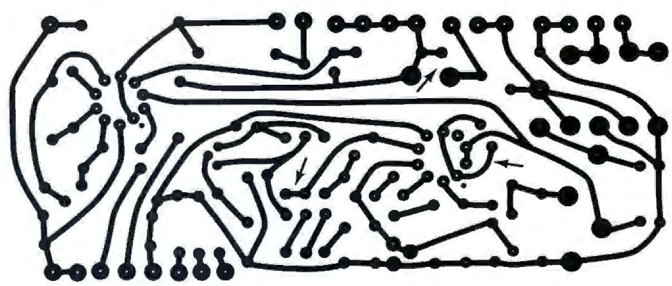
What do you mean by *defeated* U.S. Metrication Bill? Metrication Bill HR 8674 has passed the House, had hearings in a Senate subcommittee on October 8 and 9, and is now waiting to be voted on in the Senate.—*LeRoy Taraba, Portland, Ore.*

Elementary and secondary schools provide only cursory coverage of the metric system, quickly returning to the English system. Unless a student is studying science or technology, his chances of getting involved with metrics are remote.

The reference to the defeated bill was to an earlier attempt to pass some legislation. At the time we went to press with the Editorial, HR 8674 still hadn't passed the House. And as of this writing, the Senate has not yet voted on it.

Out of Tune

In "Build a Preregulated Power Supply," p 58, November 1975, the component placement guide is shown from the *component* side of the board, not the foil side. The foil pattern on the component placement guide is correct. A corrected half-size etching and drilling guide is shown below. Arrows point to areas where changes are necessary.



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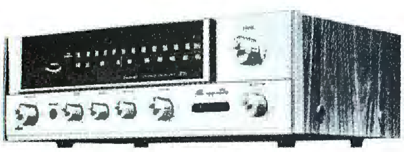
New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

SANSUI AM/STEREO FM RECEIVER

The Sansui Model 331 AM/stereo FM receiver, designed for "budget" audio systems, is rated at 12 watts rms per channel minimum output, both channels driven



into 8 ohms loads with 1% maximum THD and power bandwidth 40 to 20,000 Hz. Frequency response at 1 watt overall is 25 to 30,000 Hz +2 dB, −3 dB. Other specifications are: IHF sensitivity, 2.5 microvolts; S/N, 65 dB; selectivity, 60 dB; and capture ratio, 1.5 dB. The receiver has a frequency-linear variable capacitor, MOSFET front end, two bi-resonator ceramic filters and high-density IC's. $200.00

CIRCLE NO. 85 ON FREE INFORMATION CARD

MIDLAND MOBILE/PORTABLE CB RIG

Midland's new Model 13-861 is a 23-channel CB transceiver for mobile or portable applications. It comes with a battery pack, carrying case, and antenna for portable use. In this mode up to 3.1 watts of r-f output are available. When high power is not needed, a high/low power switch reduces transmitter output and extends battery life. The receiver section features dual-conversion superhet circuitry, agc, and anl. A three-way meter monitors r-f output, received signal strength, and battery condition. A PTT speaker/microphone is included, along with a charger jack and telescoping antenna. In mobile operation, the antenna and battery pack are disconnected, and r-f output appears at an antenna jack. A mobile mounting bracket accepts the transceiver in or out of its case, which contains the battery pack (holding 10 NiCd "AA" or 8 penlight cells). The case also has an adjustable shoulder strap and belt loop. Measures 7⅝" D × 4⅝" W × 3¼" H (17.8 × 11.8 × 8.3 cm). $164.95.

CIRCLE NO. 86 ON FREE INFORMATION CARD

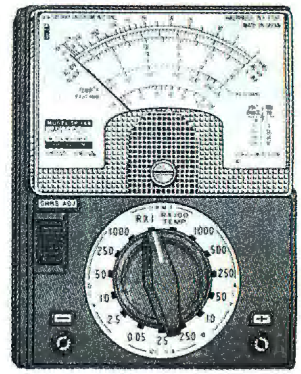
HUFCO FREQUENCY COUNTERS

Two frequency counters, Models TWS-300 (3 digits) and TWS-600 (6 digits), have been announced by Hufco TWS Labs. Both counters are said to have 300-mV sensitivity and they operate through 250 mHz. They are equipped with 115-volt power supplies, but will work with 12-V dc through a dropping resistor. The TWS-300 is $99.95 in kit form and $117.95 assembled; TWS-600 is $119.95 kit and $139.95 assembled.

CIRCLE NO. 87 ON FREE INFORMATION CARD

MULTI-TESTER WITH TEMPERATURE RANGE

The SP144 multi-tester from A.W. Sperry Instruments features a −20 to +300°F temperature range. Other standard



scales include 10/50/250/500/1000 V ac; 2.5/10/50/250/1000 V dc; .05/25/250 mA dc; 4000 and 400,000 ohms with 35-ohm mid-scale; and −20 to +62 dB. Sensitivity is 20,000 ohms/V dc and 10,000 ohms/V ac. Includes fuse, battery and test leads. Measures 4¾"H × 3¼"W × 1$^{11}/_{16}$"D (12 × 8 × 4 cm) and weighs 9 oz.

CIRCLE NO. 88 ON FREE INFORMATION CARD

TELEPHONICS STEREO HEADPHONE

The Telephonics Stereo-50 headphone features an ear cushion that has an inner, open-air supra-aural section and an outer closed-air circum-aural portion. The combination is said to provide an unusual stereo effect. A channel blend control can be adjusted by the listener. Specifications

include: frequency range, 16 to 22,000 Hz; THD, less than 0.2% at 100 dB SPL; power handling capability, 400 mW per channel. Weighs 12 oz. $50.00.

CIRCLE NO. 89 ON FREE INFORMATION CARD

HEATHKIT MODULES FOR AUDIO SYSTEMS

The heart of Heath's new "Modulus" line of audio modules is the AN-2016 Digital AM/Stereo FM Control Center. This is a tuner with digital frequency readout and a built-in stereo/quadraphonic preamp. A matching power amplifier (35 watts rms per channel or 60 watts rms per channel) may be added for stereo and a second unit for 4-channel use. Preamp specifications include: frequency response, 10 to 30,000 Hz, +0, −0.5 dB; THD, 0.05%; input sensitivities, 2 mV and 6 mV; hum and noise, −80 dB; high filters, −3 dB at 7 kHz ±1 kHz; low filters, −3 dB at 30 Hz ±2 Hz. For the FM section: sensitivity (mono) 1.7 μV IHF, (stereo) 35 μV for 50 dB S/N; separation, 40 dB at 1 kHz; selectivity, greater than 100 dB; capture ratio, 1.3 dB. It features peak-reading meters, tuning and signal-strength meters, separate bass and treble controls for front and rear channels, a "tone flat" button, low- and high-filter switches, and front-panel tape inputs and outputs. Pushbuttons light when engaged and tuner frequencies are displayed by ½" high LED's. Plug-in modules for the Control Center permit adding a CD-4 demodulator, a full-logic SQ decoder, or Dolby equalization. The AN-2016 is 19"W × 14½"D × 6½"H (48 × 37 × 16.5 cm) and costs $599.95. The AA-1505 (35-W power amp module) and AA-1506 (60-W power amp module) are 14 21/32"D × 8"W × 5⅝"H (37 × 20 × 14 cm) each and cost $159.95 and $179.95, respectively.

CIRCLE NO. 90 ON FREE INFORMATION CARD

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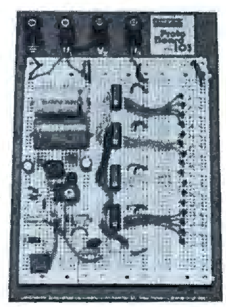

Proto-Board 103. 2250 solderless terminals save you time on every circuit you design.

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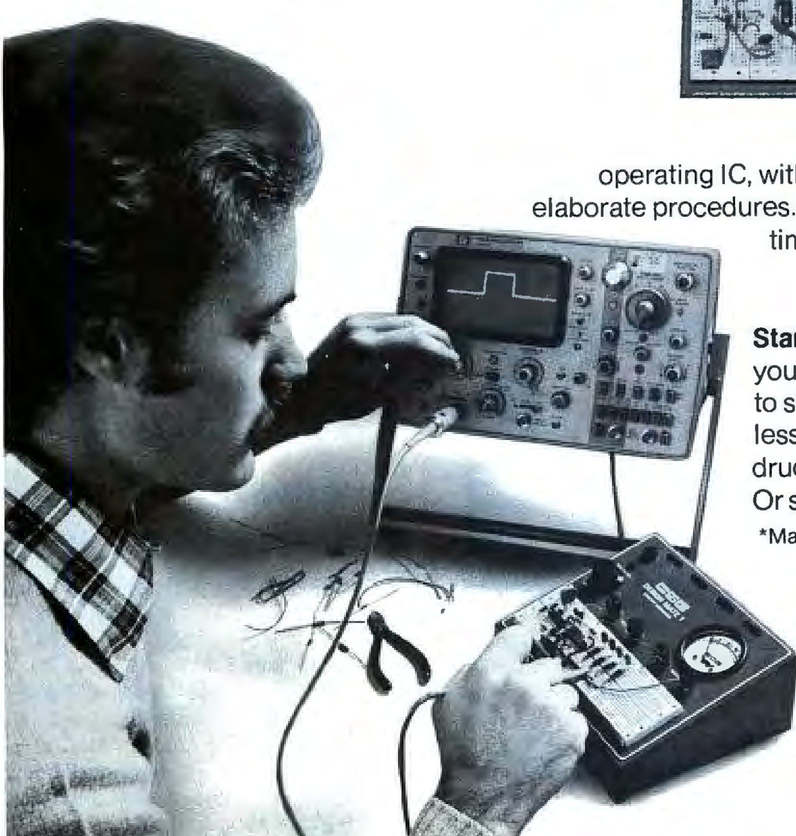

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RCA VHF/UHF SCANNER

RCA's new Model 16S400 scanning monitor has 10-channel capability, and covers 30-50, 150-174, 450-470, and 470-512 MHz. Additional features are two-speed scanning, varactor tuning, a scan delay control adjustable from 0 to 4 seconds, separate lockout switches for each channel, and a channel selector switch for manual scanning. Two power cords are provided for 12-V dc and 117-V ac operation. Also included are an external speaker jack, a mounting bracket, and separate telescoping antennas for vhf and uhf. Measures 8½" D × 7¾" W × 2⅝" H (22 × 20 × 7 cm) and weighs 4 lb, 5 oz (1.96 kg). $184.95

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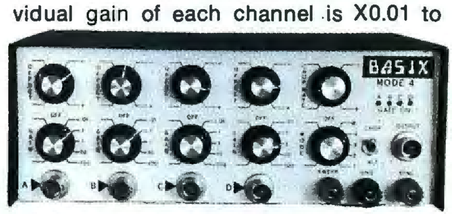
BASIX 4-CHANNEL SCOPE ACCESSORY

The Mode 4 accessory, from Basix, permits display of up to four simultaneous analog and/or digital signals on any single- or dual-channel oscillosope. Modification of the scope is not required. The user selects parallel or serial multiplex modes. Individual gain of each channel is X0.01 to



X100 in decade steps. Digital signals are processed as analog waveforms. The instrument is said to be compatible with all logic families, including TTL and CMOS. $189.

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AMTRONCRAFT EQUIPMENT CABINETS

A new series of six aluminum equipment cabinets in kit form has been announced by Amtroncraft Kits, Ltd. They range in sizes from 9¼"W × 5⅞"D × 5⅛"H (23.5 × 15 × 13 cm) to 11⅝"W × 7⅞"D × 5⅛"H (29.5 × 20 × 13 cm) and 9¼"W × 5⅞"D × 3¾"H (23.5 × 15 × 9.5 cm) to 11⅝"W × 7⅞"D × 3¾"H (29.5 × 20 × 9.5 cm). Prices are from $12.50 to $17.50. The front panels are of brushed aluminum with shock-proof plastic escutcheons. Removable tilt stands and plastic feet are included.

CIRCLE NO. 96 ON FREE INFORMATION CARD

New Literature

MODULAR POWER SUPPLY CATALOG

Calex offers a new 12-page Power Supply Catalog describing its line of modular, encapsulated power supplies. Described are single, dual and triple supplies with voltages of 5 V to ± 15 V dc, with current ratings up to 1 A. The supplies are designed for operational-amplifier, function-module, and data-conversion applications. Address: Calex Mfg. Co., 3305 Vincent Road, Pleasant Hill, CA 94523.

CTS CRYSTAL SELECTION GUIDE

A 72-page guide to crystal selection lists all standard CB, synthesized CB, monitor and 2-meter amateur crystals available from CTS Knights, Inc. Includes general information about each crystal type, as well as CB cross-reference charts, monitor and 2-meter equipment vs CTS part number listings, and frequency charts for standard and synthesized CB crystals. Available for $1.00. Address: Distributor Sales Manager, CTS Knights, Inc. Sandwich, IL 60548.

VIDEO CASSETTE NEWS LETTER

SCAN is a four-page newsletter published quarterly by Memorex for video tape users. The spring issue discusses proper handling of the video cassette, storage procedures, and the importance of cleaning both tape and machine. It also covers the adjustments a VTR user must make to match tape and machine for optimum performance. Address: SCAN, Memorex Corp., Box 420, Santa Clara, CA 95052

VECTOR ELECTRONICS CATALOG

Vector Electronic's 16-page catalog lists its 398 most preferred packaging products. Organized alphabetically, it gives features and specifications for circuit boards, cages, card cases, sockets, tern inals, Vectorboards and tools. Also listed are a variety of breadboarding kits, patchboards, turrets, positive photosensitized boards and developer. Address: Vector Electronic Co., Inc. 12460 Gladstone Avenue, Sylmar, CA 91342.

FOUR-CHANNEL AND CALCULATOR BROCHURES

Two new brochures on four-channel sound and electronic calculators have been added to the Electronic Industries Association/Consumer Electronics Group consumer information program series. The complete line of brochures includes "Tips on Television Sets," "Tips on Audio Products," "Tips on Tape Recorders & players," "Tips on Electronic Calculators," Tips on Four-Channel Sound," and "Television Safety Tips." Copies available on request. Specify desired title(s). Address: EIA/CEG, Box 19369, Washington, DC 20006.

ALARM EQUIPMENT CATALOG

Mountain West Alarm Supply Co.'s new catalog A-76 highlights available equipment and includes an alarm equipment application guide. Covered are a general alarm system discussion, installation procedures, and connection diagrams. Over 500 products are listed, ranging from relatively simple kits to the latest ultrasonic, radar, and infrared intrusion detectors. Product categories include fire and burglar systems, detectors, control instruments, remote controls, signalling devices, telephone dialers, lock specialties, tools and books. Applications, principles of operation, specifications, and connection diagrams are given. Address: Mountain West Alarm Supply Co., 4215 N. 16th St., Phoenix, AZ 85106.

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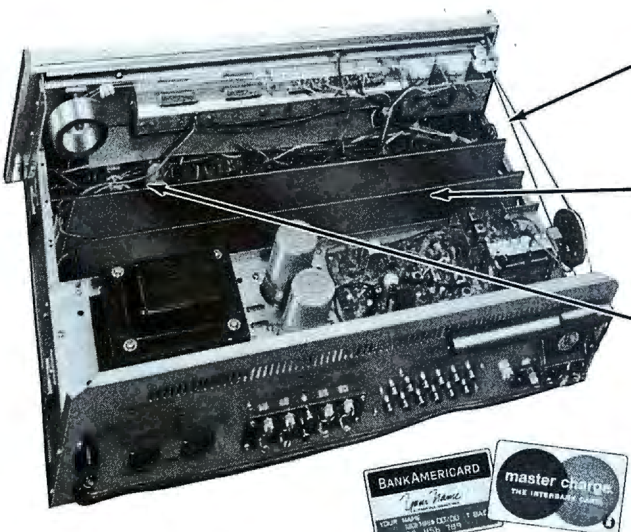

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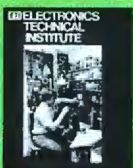

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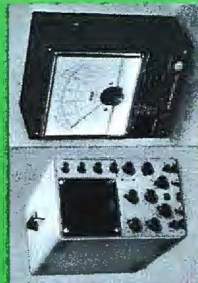

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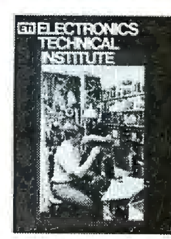

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Stereo Scene

By Ralph Hodges

LOOKING TO THE FUTURE

THE 52nd convention of the Audio Engineering Society got off to a flying start with a number of exceptionally interesting papers on disc recording. CBS Technology Center's Dan Gravereaux assured us (with the significant assistance of Jim White) that the mechanical aspects of certain widely used disc-cutting lathes are at least adequate for their intended task. Steve Temmer of Gotham Audio suggested that the electroplating process (by which the products of the lathe are turned into molds for phonograph records) may not be. And Mr. S. K. Khanna of RCA Records demonstrated, as exhaustively as he could in the time allotted, that the vinylite material from which phonograph records are molded is a difficult medium that is little understood, particularly in terms of its flow properties, its elasticity, and the effect of temperature on both these characteristics.

I consider these papers important because they point out where we should and shouldn't be looking for problems encountered in records we routinely buy from stores. But the paper that really brought the house down was given by Tomlinson Holman (Advent Corporation) on the subject of phono preamplifiers.

Phono Preamplifiers. As you're no doubt aware, a phono preamplifier is a gain and equalization stage present in every receiver or amplifier intended to be used with a magnetic phono cartridge. It receives the output of such a cartridge directly (through an interconnecting cable of course) and attempts to turn it into a signal comparable to what would be received from a typical high-level program source, such as a tuner or a tape deck with electronics. Usually it's a simple device, involving as few as two bipolar transistors per channel and a small handful of capacitors and resistors. Ordinarily, nobody thinks too much about it, as witnessed by the way most specification sheets give an S/N figure for the phono preamplifier but nothing else. When you see distortion values for any electronic audio component you can depend upon the fact (unless specifically stated otherwise) that the phono preamplifier stage has been bypassed and is not included in the total. In short, the preamp is an unknown quantity.

Lest this begin to sound like the scandal of the year, let me say that most phono preamplifier sections are reasonably good by most measurement standards. You won't find too many of them that test out at 0.01% total harmonic distortion, but the days in which you could see 5% THD at certain frequencies (with input levels that should be acceptable) are pretty much past. Still, in the opinion of many people, some phono preamplifiers definitely sound different from others, and the reasons for their doing so are evidently not crystal clear.

As one who shares this opinion, I found Mr. Holman's data quite arresting, especially since his subjective impressions of these audible differences seem to correspond so well with my own. He speaks of them as sounding like frequency-response errors,

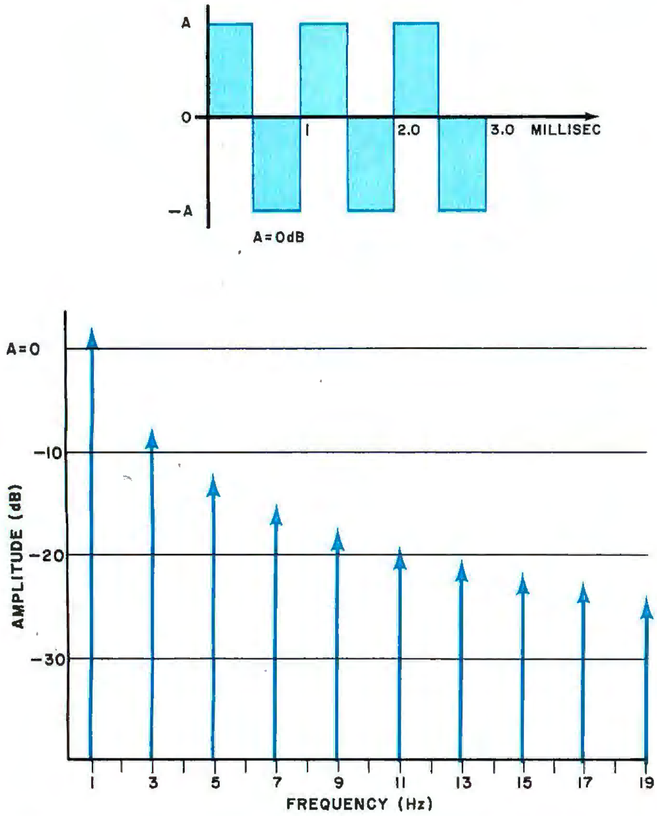

Fig. 1. In spectrum analysis of 1-kHz square wave (top), no even overtones are present.

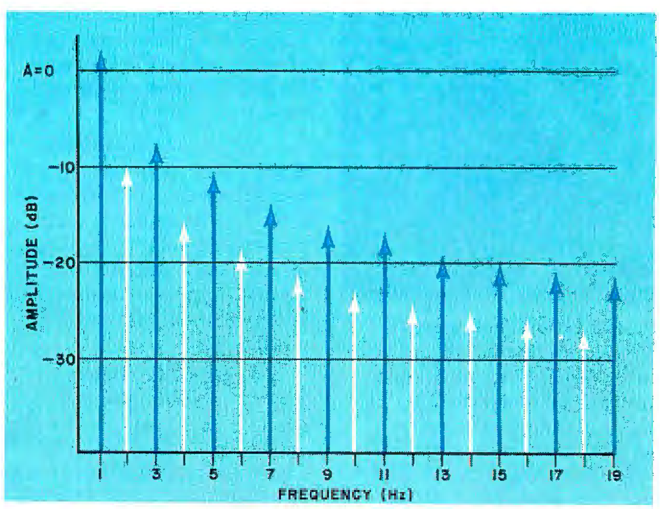

Fig. 2. In a poor preamplifier, second-harmonic distortion is only 13 dB below fundamental (borne out by listening tests).

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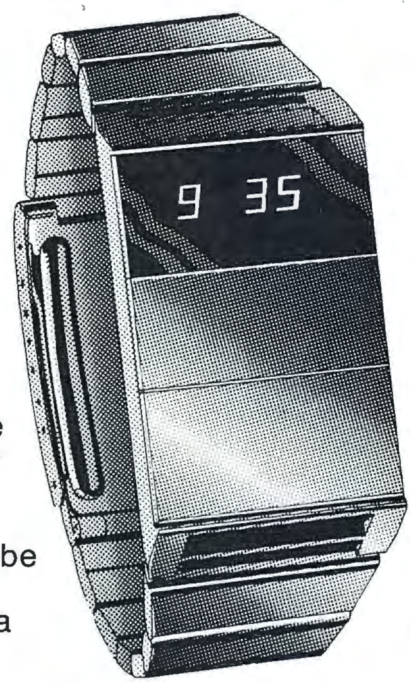

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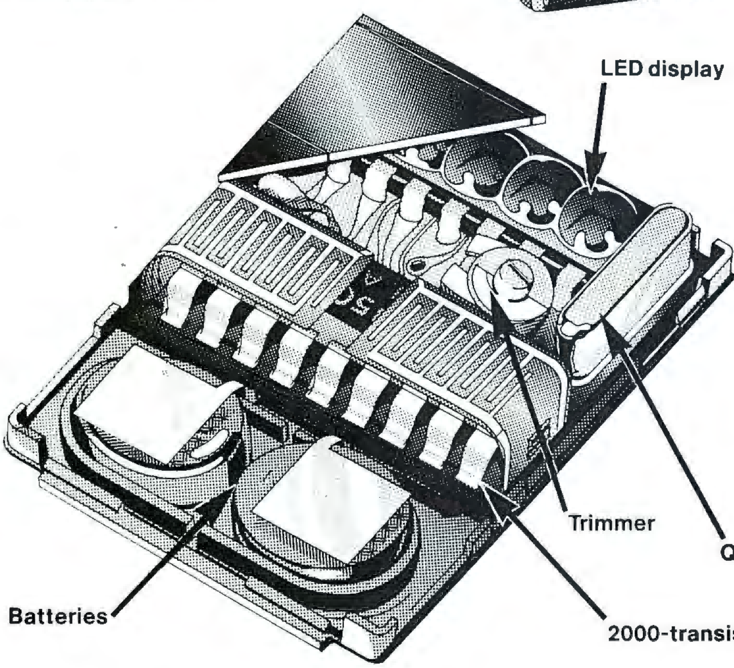

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". . .most often having the quality of 'brighter' vs 'duller.' " If they were frequency-response errors they would presumably be amenable to simple tone-control correction. But I don't find them always to be so; and apparontly Mr. Holman agrees.

In fact, he notes that it is sometimes possible to run a frequency-response test on one of the bright-sounding preamplifiers (taking care to include all the relevant characteristics of the phono cartridge in the measurement) and find that it actually has a subdued high end compared with another preamplifier that doesn't sound as bright—a phenomenon that I have also encountered.

The first part of Holman's paper essentially dealt with matters that are pretty much accepted: the complex interface of preamplifier and cartridge (which is mentioned in more and more equipment test reports of late); the cartridge as a noise source (again an interface-related factor); and the potentially harmful effects of permitng subsonic frequencies (from record warps and vibration sources) to lie within the passband of the preamplifier. In the second part of the paper, Holman discussed a test devised to rank phono preamplifiers in terms of listener preference.

The test assumes that all the above interface factors have been properly attended to. Then, through a cartridge-simulating network, an RIAA pre-equalized 1,000-Hz square wave is introduced into the amplifier and the output studied with a spectrum analyzer (Fig. 1). What Holman observed after doing this with a variety of preamplifiers was (aside from the expected sequence of odd-order harmonics) significant even-order harmonics that were not present in the input signal. In the worst case, second harmonic distortion, down 67 dB in the input, was down only 13 dB in the output of the preamplifier (Fig. 2). Holman also reports that the preferences of listeners auditioning the preamplifiers under controlled conditions correlated almost perfectly with the absence of these spurious harmonics.

The interpretation of this test in terms of circuit design was questioned by a number of people in the convention audience. (In fact, Holman's paper notes several possible causes for the problem without citing any one as being prevalent in the products he evaluated.) Some were openly critical of the test as being no more than a trivial demonstration of the various preamplifiers' overload characteristics, carried out with a test signal that is not adequately representative of a real phono cartridge's output. I can understand such sincere reservations, but I am becoming a little frustrated with the audio industry's reluctance to look harder at new and sometimes unconventional test procedures, particularly when they apparently correlate meaningfully with listener reactions. In many areas, evidence is mounting that static sinewave tests are not unconditionally representative of the performances of a device that will have to handle music signals. We do not have any really agreed-upon standards for dynamic test signals and probably won't for some time. But I don't think this is an excuse to ignore the whole matter.

It is becoming rather fashionable to say, without further investigation, that any dissimilarities one hears between preamp A and preamp B have to be the result of minute frequency-response and level differences. This is a convenient attitude to take because we know that such differences can have profound subjective effects, and because if we look hard enough we can always find *some* slight response difference between two preamplifiers to bear all the blame. Undoubtedly this is the correct explanation in many instances, but people like Holman don't believe it holds true always; and I feel they deserve a better hearing.

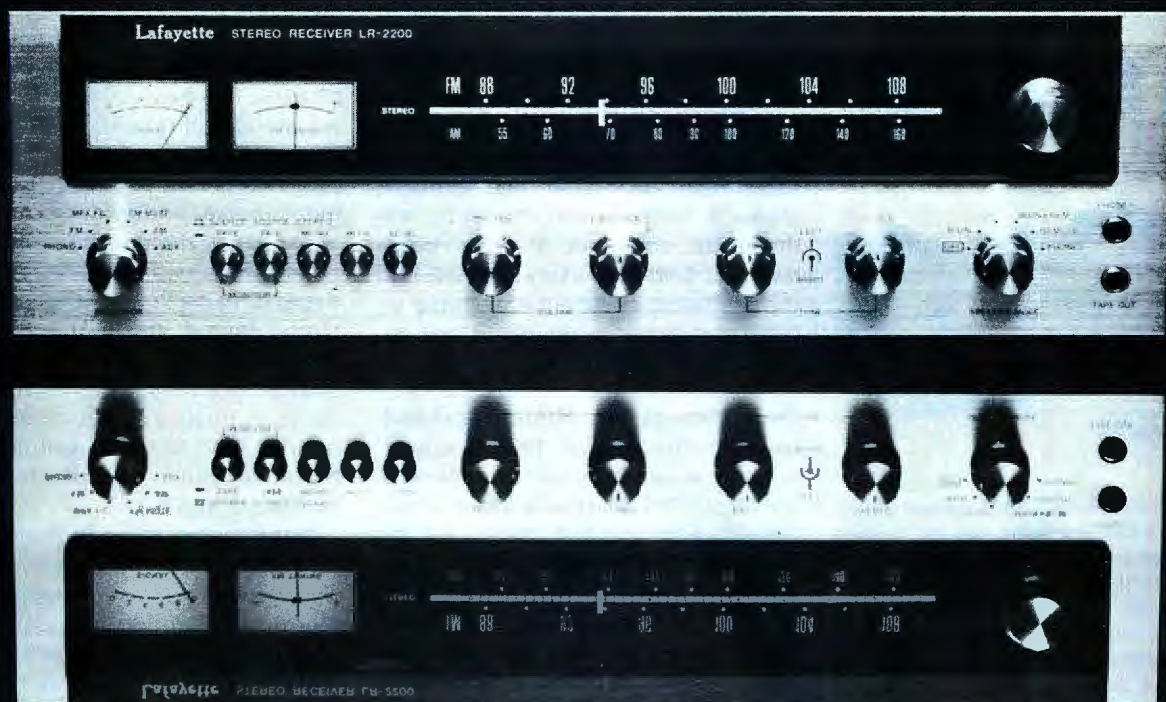
Listening to Light. Wireless microphones and headsets are certainly not new, but so far they have failed to perform up to the standards of the serious audio buff. That situation may have changed materially if spokesmen for Beyer (Revox Corp. in the U.S.) and Sennheiser are correct. The development responsible for this is an LED that, radiating exclusively in the infrared region, makes beam-of-light transmission of audio signals practical and relatively inexpensive. Both the aforementioned companies offer very compact transmitters and even smaller receivers in pocket-size modules or built into light-weight headsets. The Beyer setup costs just under $100 for the transmitter and about $75 for a battery-powered receiving module. The Sennheiser system will ultimately be made available in stereo at a somewhat higher price. Apparently such devices have become popular as built-in accessories for TV sets in Europe, although their first U.S. appearance in commercial form was at the AES convention.

The especially interesting thing about the technique is that it is reportedly interference-free as long as reasonable distance and line-of-sight conditions are maintained, along with suitable lighting in the environment (illumination that is heavy—particularly near the infrared spectrum—can evidently saturate the receiving sensors). Multipath effects could not be induced during my brief trial of the device, and small infrared sources such as lighted cigarettes and pipes did not seem to affect it.

In a typical configuration (Sennheiser), the baseband audio frequency modulates a subcarrier which amplitude-modulates a 95-kHz sub-carrier that in turn amplitude-modulates the infrared source. Adding additional sub-carriers permits multichannel transmissions. Naturally, since the FCC is mute on the subject of infrared transmissions, there are as yet no restrictions on bandwidth and dynamic range, nor are there likely to be any. Given this and the freedom from interference, it might just be possible—with the right electronics—to get a true high-fidelity signal from here to there on a light beam as readily as we do today with an audio cable.

Teac and DBX. Late word has it that the Teac/Tascam group has become the first equipment licensee for the DBX compander-type noise-reduction system. The first consumer tape machine to contain the system should be available before you read this. The marriage was apparently made possible by the emergence of the DBX circuitry in IC form.

This looks to be a promising development, since several people have indicated to me that the excellent results they've gotten with the DBX system has rejuvenated their interest in live recording. Of course, the Dolby B system so widely used in cassette recording was received with similar accolades some years ago, and it is also a compander technique. However, the Dolby designers wished to maintain some degree of compatibility with tape machines not equipped to decode Dolbyized tapes, and thus restricted the action of the compression-expansion cycle to frequencies above 2000 Hz. By contrast, the DBX



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system acts on all frequencies to such a radical extent that DBX-encoded material is unlistenable unless properly decoded during playback.

Intrigued by the reports of DBX's effectiveness, I duly presented myself at the DBX demonstration room at AES and was again taken aback by the huge, undistorted sounds that can emerge from an uncannily quiet background when this processor is used. The DBX staff had brought along a tape or two made by enthusiastic amateurs in their basements and other unlikely settings, and the technical excellence of these efforts surpassed anything in my experience and all my expectations.

Department of Misunderstandings. In the August 1975 "Letters" column, a well-informed communication from Mr. M. Howard Lieberman argued, among other things, for the importance of maintaining interchannel phase integrity when adjusting the azimuth of tape heads. My reply, which appeared with the letter, declared that in this context I didn't think phase was very important at all. After this incautious remark I really got the works from a number of readers, who took me to task for everything from advocacy of random phase reversal to ignorance of the principles of stereo. I am not guilty, I hope, but I perceive there is a misunderstanding afoot. An amplification of my statements (which were edited to save space) may clear things up.

To paraphrase Mr. Lieberman's comment: a tape head that has been aligned for the best maximum-output compromise between the two channels with a 10,000-Hz test signal may still introduce a phase shift of 180 degrees or more between the channels at that frequency. As far as I know, this is exactly right, but it is not as serious as it sounds. A 180-degree phase shift (indicating a completely out-of-phase condition between channels) means, in effect, that one tape-head gap leads or lags the other on the tape by one half wavelength, which (at 10,000 Hz and 7½ ips) is a displacement of 0.000375 inch. But at 1000 Hz the same displacement results in a phase shift of only 18 degrees, and at lower frequencies, where wavelengths get longer, the phase shift becomes smaller and smaller. This is not, in other words, a situation in which the tape machine's channels can be described as being out of phase.

Another way of looking at it is to consider the gap displacement as a time displacement between channels; one channel's speaker emits its output one twenty-thousandth of a second later than the other, so that 10,000-Hz signals from the speakers arrive at a point equidistant between them out of phase. Now 10,000 Hz has a wavelength of roughly an inch in air. If we move the listening position an appropriate distance closer to the lagging speaker and away from the leading speaker, their outputs will fall into phase and all will be well. In this case, depending on the geometry of the listening layout, the required position shift would be on the order of one quarter of an inch. But be sure not to let your head nod so much as one quarter inch to either side as you sit there, or you'll be out of phase at 10,000 Hz again.

I don't want to pooh-pooh the significance of such phase shifts. Obviously, when you're just listening to a stereo tape through speakers, they are trivial, and even uncontrollable. But if you had it in mind to *mix* identical tape tracks on a machine with this kind of phase shift you'd run into deep frequency-response troubles. And in the professional sphere—particularly today, when it's necessary to maintain precise phase relationships in the mixing of matrix four-channel tape masters—phase considerations are vital (and studio tape speeds of 15 ips make them easier to deal with)

Actually, it would be ideal if consumer tape machines were designed so that an azimuth adjustment that brought the channels exactly into phase also resulted in optimum frequency response for all channels. Unfortunately, it doesn't turn out that way as a rule. With current manufacturing techniques, it is supremely difficult to keep the several gaps in a tape head perfectly lined up. Also, as I understand it, there can be some ambiguity as to where the magnetic gaps (as opposed to the physical gaps) really are. And then there are also tape-motion problems.

A spokesman for Tandberg, a company known for its scrupulous attention to head alignment, states that, up to now, they have not been able to take much account of phase in adjusting their machines. However, he notes that a new head going into production should be close enough in manufacturing tolerances to permit phase and response to match up. ◈

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Each port of the *new parallel interface board* provides 16 data lines and four controllable interrupt lines. Each of the data lines can be used as an input or output so that a single port can interface a terminal requiring 8 lines in and 8 lines out. All data lines are TTL compatible. *The 88-4PIO regularly sells for $86 kit and $112 assembled.*

Software. Altair 4K BASIC leaves approximately 725 bytes in a 4K Altair for programming which can be increased by deleting the math functions (SIN, SQR, RND). This powerful BASIC has 16 statements (IF . . . THEN, GOTO, GOSUB, RETURN, FOR, NEXT, READ, INPUT, END, DATA, LET, DIM, REM, RESTORE, PRINT, and STOP) in addition to 4 commands (LIST, RUN, CLEAR, NEW) and 6 functions (RND, SQR, SIN, ABS, INT, TAB, and SGN). Other features include: direct execution of any statement except INPUT; an "@" symbol that deletes a whole line and a "←" that deletes the last character; two-character error code and line number printed when error occurs; Control C which is used to interrupt a program; maximum line number of 65,529; and all results calculated to seven decimal digits of precision. *Altair 4K BASIC is regularly priced at $60 for purchasers of an Altair 8800, 4K of Altair memory, and an Altair I/O board. Please specify paper tape or cassette tape when ordering.*

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news HIGHLIGHTS

Stereo By Satellite

The first intercontinental stereo relay to the UK took place in late Spring when BBC Radio 3 carried the final concert of the BBC Symphony Orchestra's tour of Japan. The live program was transmitted first to a Japanese earth station near the southern tip of the main island of Honshu, then to the Intelsat IV satellite which is in a geostationary orbit about 35,000 km (21,700 miles) above the Indian Ocean. Signals were beamed from the satellite to a British Post Office earth station in Cornwall, and ultimately through the BBC's pulse code modulation (PCM) system to the Radio 3 transmitter network. Reception was reported to be excellent.

1976 Student Computer Fair

The 1976 National Student Computer Conference will sponsor its NCC Student Computer Fair during its June 7-10 meeting in New York City. Elementary, middle, and high school students are eligible to enter projects in the fair. The deadline for submittal of application forms is April 1, 1976. It is hoped that students will concentrate on the social situations they know best. The entry categories are being broadened this year to include computer art and music, short stories, science fiction, and poetry. Elementary students, for example, may submit drawings of a computer. Of course, such projects as computer games, and computer tools for home or school use are also welcome. First Prize is an Altair 8800 Computer Kit, plus a two-year subscription to *Creative Computing* magazine. For entry rules, application forms, etc., write to: 1976 NCC Student Computer Fair, C.U.N.Y., 33 W 42nd Street, New York, NY 10036

SCA Services For The Blind

To provide blind people with "talking book" entertainment, groups in 11 cities are now using SCA (Subsidiary Communications Authority) subchannels of FM broadcast stations. For example, Radio Information Center for the Blind (919 Walnut St., Philadelphia, PA 19107), operates an SCA service for the sightless within WUHY-FM's 90.9-MHz allocation. Programming totals 88 hours per week, running from 10 a.m. to 11 p.m. Monday through Saturday, and 1 p.m. to 11 p.m. on Sunday. RICB reports that it has distributed, free of charge, over 1300 crystal-controlled receivers (tuned exactly to the subchannel) to blind people in the WUHY service area.

Interestingly, each night from 10 to 11 p.m., Monday through Friday, RICB has an "Adult Book Hour" when books dealing with sexual themes are read. This is done in response to listener requests, as they want access to the whole range of literature that other adults have. The FCC's obscenity regulations do not apply to these programs, as they are not available to the general public and are not literally "broadcast."

Such programming is available in a number of other cities, including Columbia, SC; Washington, DC; Seattle; St. Paul (this group operates 5 transmitters across Minnesota); E. Lansing, MI; Belleville, IL; Lawrence, KS; Oklahoma City; and Erie and Lancaster, PA. Other groups are planning similar SCA services in San Diego, Madison, WI, Salt Lake City, Boston, New York, Harrisburg, Pittsburg, Knoxville, and Nashville.

14 Hours On Cassette

Answerline Associates, Mt. Vernon, N.Y., using a tape speed of ⅜ ips and a "Magnapulse" recording head, has produced a cassette recorder (Model LP5A) that will record up to 14 hours of material on a standard C-180 high-energy cassette. The recorder is expected to be applied to voice and data recording, physiological information storage, etc. An optional voice actuator with a 75-ms start time is also offered.

Computer Museum

The Bicentennial Commission of Pennsylvania has recognized the Computer Museum to be established at the U. of Pennsylvania as an official bicentennial project. It will be housed in Penn's Moore School of Electrical Engineering, site of the development of ENIAC, the first large-scale electronic digital computer, which was dedicated on February 15, 1946. Components of ENIAC, on loan from the Smithsonian Institution, will hold a key spot in the exhibition area. Also on display will be a mechanical differential analyzer developed at the Moore School in 1935, as well as parts or replicas of other early computers developed there. Visitors will also see an operating modern computer, the Univac 70/46, and will be able to use a hands-on terminal to play simple games, experiment with displays such as the structure of atoms, and ask questions about Museum exhibits. ENIAC employed 18,000 vacuum tubes, 500,000 soldered joints, 10,000 capacitors, and 70,000 resistors. It weighed more than 30 tons (272,400 kg), occupied 1,500 square feet (139 m^2) of floor space, and could perform 5,000 calculations per second—spectacular for its time.

The Audio Accessories Market

Americans are expected to have spent over $415 million at retail outlets in 1975 for audio accessories, according to a Zenith Radio Corp. spokesman. Some $286 million of the total went for blank 8-track and cassette tapes. Audiophiles who want to keep their sounds to themselves spent $58.5 million for two- and four-channel headphones. Expenditures of $3.25 million were made for such items as cable connectors and cables, chemicals for tape-head cleaning, etc., and speaker wire. External FM antenna sales added up to $1.3 million.

Joint Group Studies AM Stereo

This Fall, a study was undertaken by three industry organizations to determine the best method AM radio stations may use to broadcast stereo programming. The National Association of Broadcasters, the Electronic Industries Association, and the IEEE have set up the National AM Stereophonic Radio Committee at the request of the FCC, to which findings will be reported.

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BY TERRY WALKER,
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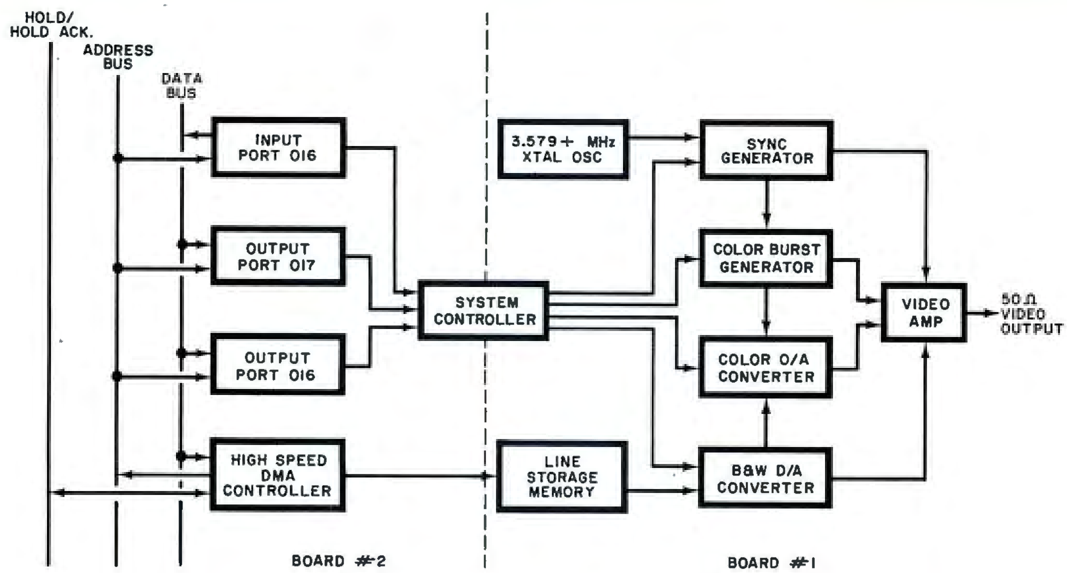


PARTS LIST

C1 through C9,C18 through C25—0.1-μF disc ceramic capacitor
C10,C11,C26,C27—47-μF, 20-volt tantalum capacitor
C12—330-pF disc capacitor
C13—680-pF disc capacitor
C14,C15,C16—470-pF disc capacitor
C17—9-35-pF variable capacitor
D1—1N914 silicon diode
D2—1N5242B, 12-volt zener diode
IC1,IC37—LM340-5.0, 5-volt regulator
IC2,IC16,IC17,IC18—SN7410N triple 3-input positive NAND gate
IC3,IC10—SN7473N dual J-K master-slave flip-flop
IC4,IC21,IC56—SN7432N quad 2-input OR gate
IC5,IC30—SN7430N 8-input positive NAND gate
IC6,IC23,IC42,IC43—SN7474N dual D-type edge-triggered flip-flop
IC7,IC19,IC35,IC40,IC48—SN7404N hex inverter
IC8,IC22,IC25,IC39,IC51—SN7408N quadruple 2-input positive AND gate
IC9,IC14,IC15,IC28—SN7400N quadruple 2-input NAND gate
IC11,IC12,IC31,IC32,IC49,IC50,IC52—SN7493N 4-bit binary counter
IC13,IC27,IC33,IC45—SN74157N quadruple 2-input data selector
IC20,IC29—SN7420N dual 4-input positive NAND gate
IC24—F3342DC 64 x 4 MOS shift register (Fairchild)
IC26—SN74151N 8-line to 1-line data selector
IC34,IC46,IC54—SN74175N quadruple D-type edge-triggered flip-flop
IC36,IC53,IC55,IC61,IC63,IC64—SN7475N quadruple bistable latch
IC38—SN7402N quadruple 2-input positive OR gate
IC41—SN74LS10N triple 3-input positive NAND gate
IC44—SN74LS30N 8-input positive NAND gate
IC47—SN74LS08N quadruple 2-input positive AND gate
IC57—SN7495N 4-bit universal shift register
IC58,IC59,IC65,IC72,IC73—SN74LSO4N register
IC60,IC62—SN7483N 4-bit binary full adder
IC66,IC67,IC74—SN7405N hex inverter with open collector
IC68,IC69,IC70,IC71—SN74367 hex tri-state buffer
Q1—2N3904 transistor
Q2,Q3—2N3906 transistor
Following resistors are 5%, 1/4 watt:
R1—150 ohms
R2,R3—1000 ohms
R4—470 ohms
R5,R6,R7,R29—1200 ohms
R8,R10—9100 ohms
R9—18,000 ohms
R11—7500 ohms
R12—15,000 ohms
R13—62,000 ohms
R14—30,000 ohms
R15 through R20—13,000 ohms
R21—820 ohms
R22—1500 ohms
R23—330 ohms
R24—220 ohms
R25—51 ohms
R26—100 ohms
R27—22 ohms
R28—680 ohms
R30,R31,R32—500-ohm trimmer potentiometers
XTAL—3.579545 MHz
Misc.—IC sockets (74), heat sinks (2), mounting hardware
Note: The following are available from Cromemco, 1 First St., Los Altos, CA 94022: complete set of parts less IC sockets at $195; with IC sockets at $215, assembled and tested Dazzler for $350. California residents please include sales tax. Prices include postage for orders shipped within the U.S. Partial kits are not available. The schematic and foil patterns are available *free of charge* by sending a stamped (for 3 oz.) self-addressed 9" by 12" envelope to Cromemco, 1 First St., Los Altos, CA. 94022.

Fig. 1. Board 1 of the Dazzler contains an NTSC color TV signal generator with output through a 50-ohm line. Board 2 communicates with the computer and modulates the TV signal.

cost of a black-and-white terminal; and you do not need an RS-232 interface. The Dazzler can be built for less than $200.

If you use your computer for business or accounting, the Dazzler can display multi-colored graphs of stored data. It can also be used to display a picture produced by the Cyclops solid-state camera (POPULAR ELECTRONICS, February 1975). With the Cyclops picture either processed or unprocessed, the system can be used for security purposes, pattern recognition tests, and measurement and control of processes.

How It Works. A block diagram of the Dazzler is shown in Fig. 1. Most of the components on board #1 are used to generate a conventional NTSC (National Television Standards Committee) color video signal. The circuit is terminated in a 50-ohm, 1-volt output. This signal can be used to drive the

OUTPUT PORT 016

	D7	D6	D5	D4	D3	D2	D1	D0
ALTAIR 8800 SENSE SWITCHES	ON/OFF	A15	A14	A13	A12	A11	A10	A9

STARTING ADDRESS OF PICTURE IN MEMORY

Fig. 2. Configuration of the data bits at output port 016.

video amplifier of a color set or to modulate a class-1 TV device connected to the set's antenna terminals (using a locally unoccupied channel).

The components on board #2 are used to communicate with the computer, with a high-speed DMA controller as the basis. The controller issues a "hold" command when it is ready to access the computer memory. When the computer is ready, it issues a "hold acknowledge" command and the DMA begins operation.

Communication between the Dazzler and the host computer is through output ports 016 and 017 and input port 016. One bit of output port 016 is used to turn the Dazzler on and off, and the remaining seven bits are used to set the starting address of the picture in the computer memory. The organization of output port 016 is shown in Fig. 2.

Output port 017, whose organization is shown in Fig. 3, is used to set the format of the TV picture. Note that bit D7 is not used. Bit D6 is used to set normal resolution (32 x 32 for 512 bytes or 64 x 64 for 2K bytes) or 4X resolution (64 x 64 for 512 bytes or 128 x 128 for 2K bytes). Bit D5 sets the amount of computer memory, starting at the location given to output port 016, allocated to the picture. When 512 bytes are selected, the computer memory must have an access time of at least one microsecond. When 2K bytes are used, the memory must have an access time of at least 500 nanoseconds.

Bit D4 is used to select either a black-and-white or color display. In the 4X resolution mode (D6 at a 1), bits D3 to D0 are used to set the color of the display when in the color mode or the intensity when D4 is in the black-and-white mode. Bits D3 to D0 are not used in the normal resolution mode.

Only two bits of input port 016 are used. When bit D7 is a 1 (high), it indicates that the Dazzler is enabled (bit D7 of output port 016 actually performs the enabling), while bit D6 goes low to indicate an end of frame. This latter bit is useful when changing frames in rapid succession.

To generate a TV picture with the Dazzler, the information that the Dazzler reads from the computer memory must be properly formatted. In the 4X resolution (output port 017, bit D6 high), each point on the TV screen is controlled by just one bit in the computer memory. This bit turns its corresponding point in the picture on or off. The color or intensity of that frame of the picture is set by bits D3 through D0 of the control word at output port 017. To get full color in the 4X mode, multiple frames of different colors must be interleaved.

In the normal resolution mode (output port 017, bit D6 low), the color and intensity of each point on the screen is controlled by a four-bit "nybble" in the computer memory. Two points of the picture are thus encoded in each byte of the computer memory. For this reason, a 64 x 64 picture requires 2K of

Output Port 017

D7 - not used

D6
- 1 Resolution X4. Color and intensity set by D4 through D0.
- 0 Normal resolution (32 x 32 for 512 bytes, 64 x 64 for 2K bytes). Color and intensity set by 4-bit words in computer memory.

D5
- 1 Picture in 2K bytes of memory
- 0 Picture in 512 bytes of memory

D4
- 1 Color picture
- 0 Black-and-white picture

D3
- 1 High intensity color
- 0 Low intensity color

Most significant bit of 4-bit B/W intensity

D2
- 1 Blue
- 0 No blue

*

D1
- 1 Green
- 0 No green

*

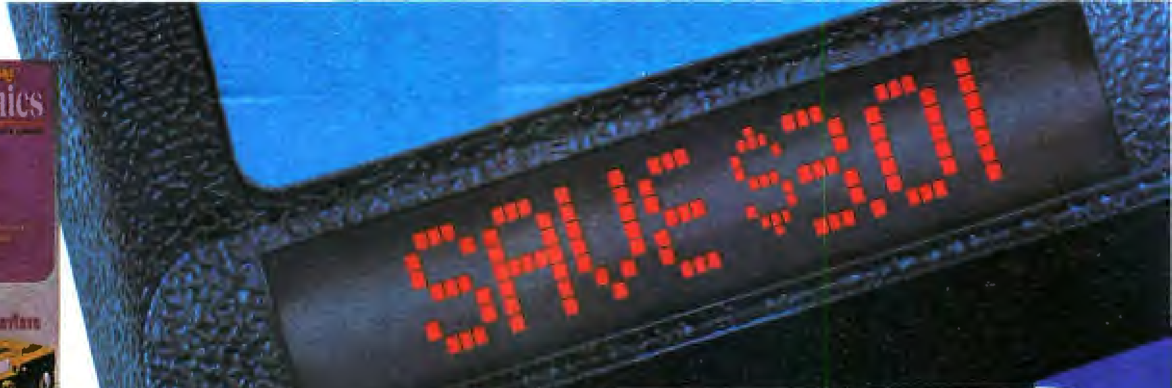
D0
- 1 Red
- 0 No red

Least significant bit

Fig. 3. The states of seven data bits at output port 017 determine resolution of TV picture and either chroma or monochrome parameters.

Memory Location	Memory Contents	Comments
000 000	076	Move immediate into
000 001	200	the accumulator.
000 002	323	Output to port
000 003	016	number 016.
000 004	333	Input
000 005	377	from sense switches.
000 006	323	Output to port
000 007	017	number 017.
000 010	303	Jump to
000 011	000	memory location 000
000 012	000	000.

Fig. 4. A test program to be used on the TV Dazzler.



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memory storage. The lowest order (D0) bit determines if the display is red, D1 is green, D2 is blue, and D3 determines either a high- or low-intensity color. In black and white, these four bits are used to determine one of 16 shades of gray.

Construction. The Dazzler consists of two adjoining pc boards that plug directly into the Altair-8800 bus connectors. The video output is taken from a pad on board #1. The schematics, etching and drilling guide and component placement diagram for the boards are too large for reproduction here. They can be obtained FREE by sending a stamped, self-addressed 9" by 12" envelope to Cromemco, 1 First St., Los Altos, CA 94022. (These items are also included with each kit as mentioned in the Parts List.)

In assembling the pc boards, note that all components are mounted on one side of the board, with all soldering on the opposite side. The sides to be soldered are those on which the foil marking can be properly read. Plated-through holes assure contact on the component side. If desired, sockets can be used for mounting the IC's. When soldering, use a low-wattage iron and fine solder. Inspect your work to make sure you have no solder bridges.

Because portions of the Dazzler operate at very high frequencies, it is important that all components be mounted close to the pc board. Be sure to use components that meet the required specifications—some untested IC's may not have the required switching speeds.

There are 36 IC's on board 1, plus the color crystal oscillator, and associated passive components. A heat sink is used for *IC1*, the 5-volt regulator on board #1. When mounting the color-burst crystal, use a small length of wire soldered from the metal case of the crystal to the ground foil immediately above the case. This reduces noise pickup.

One of the center dual in-line positions in the bottom row of board #1 is used for board-to-board interconnections rather than an IC.

There are 37 IC's on board #2. One dual in-line position is left open for interconnections. To connect the two boards, use sixteen 8" lengths of insulated wire (or a 16-conductor flat cable).

The two boards are attached using ⅝" spacers at each corner hole, with

THE GAME OF LIFE

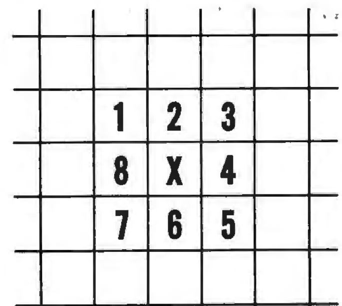
One of the most fascinating uses of the Dazzler is in playing what is known as "The Game of Life." (See *Scientific American*, October 1970, p 120; February 1971, p 112; April 1971, p 116.) The game is started by entering the program shown below. (A paper tape of the program is available for $15 from Cromemco, 1 First St., Los Altos, CA 94022.) Then a colony of cells is entered to appear on the TV screen on a 64 x 64 grid.

Each cell in the colony has eight possible neighbors, as shown at right. The evolution of the colony proceeds according to a fixed set of rules invented by John Conway at the University of Cambridge. Every cell with two or three neighbors will survive to the next generation. Every cell with four or more neighbors dies from over-population. Every cell with one neighbor or no neighbors dies from isolation. Every cell with exactly three neighbors is a birth cell—a new cell is born here in the subsequent generation.

In the Dazzler version of The Game of Life, blue represents life; birth generates a green cell; and death is shown in red. There are many surprises to be found in the game. Some colonies survive and prosper; others reach a stable state—neither growing nor lessening. Other colonies fade from existence. Some colonies, known as "gliders" sail across the screen and can be devoured by other colonies in the process.

The full-color illustrations on the first page of this article are actual photos of a TV screen several generations into a Life program.

The initial colony of cells is drawn on the TV screen using ASCII keyboard inputs as controls. Control A deposits a cell of life on the screen. Controls N, O, P, and H step the cursor up, down, right, and left, respectively. Once the initial colony is complete, Control D is initiated to start the game.



Each cell has 8 possible neighbors.

Program for Game of Life is below.

```
DAZZLE-LIFE PRØGRAM    (LØADS BEGINNING 000 000, RUNS FRØM 000 000)

ØCTAL·LISTING (000 000 = 061, 000 001 = 000, 000 002 = 010 ETC.)

──────►

061 000 010 315 265 001 315 335 001 315 175 000 315 142 000 315
222 000 315 142 000 333 377 027 332 125 000 027 332 106 000 303
111 000 311 002 002 002 002 002 002 002 002 002 002 002 002 002
002 002 002 002 002 002 002 002 002 002 002 002 311 001 000 000
315 324 000 076 100 014 271 302 200 000 016 000 004 270 302 200
000 311 001 000 000 315 064 001 376 011 302 245 000 076 000 315
105 001 303 257 000 376 012 302 257 000 076 004 315 105 001 076
100 014 271 302 225 000 016 000 004 270 302 225 000 311 041 000
010 021 000 370 006 000 076 000 272 302 316 000 273 310 160 023
043 303 310 000 305 076 000 271 302 354 000 015 315 034 001 062
164 002 301 305 315 034 001 062 165 002 301 305 014 315 034 001
041 165 002 106 167 200 053 116 160 201 127 301 310 325 315 064
001 321 376 000 312 023 001 172 376 003 310 376 004 310 076 011
303 105 001 172 376 003 300 076 012 303 105 001 005 303 176 002
004 315 052 001 004 315 052 001 172 311 325 315 064 001 321 376
000 303 206 002 315 141 001 176 332 076 001 346 017 311 346 360
007 007 007 007 311 346 017 365 315 141 001 321 332 125 001 176
346 360 202 167 311 172 007 007 007 007 127 176 346 017 202 167
311 041 000 010 170 346 040 312 156 001 021 000 002 031 171 346
040 312 170 001 021 000 004 031 171 346 037 007 007 007 027 137
076 000 027 127 031 170 037 365 346 017 137 026 000 031 361 311
333 000 346 040 300 014 302 220 001 004 302 220 001 311 333 000
346 002 312 236 001 170 323 001 311 106 076 000 270 310 315 236
001 043 303 251 001 315 276 000 076 204 323 016 076 260 323 017
041 163 002 315 251 001 315 220 001 312 306 001 333 001 107 315
236 001 346 177 376 131 310 043 163 002 303 236 001 043 163 002
315 236 001 303 214 002 315 102 002 303 166 002 127 227 276 312
346 001 172 276 312 375 001 043 043 043 303 355 001 043 136 043
126 353 315 010 002 303 346 001 351 001 062 002 002 071 002 004
050 002 010 100 002 011 067 002 017 060 002 013 052 002 015 056
002 016 076 002 000 000 000 000 301 311 021 000 000 311 006 000
014 311 076 017 315 105 001 004 311 076 000 303 064 002 015 311
005 311 315 064 001 365 305 076 014 315 105 001 021 370 370 315
220 001 302 157 002 301 305 076 000 315 105 001 021 370 370 315
220 001 301 312 106 002 361 315 105 001 333 001 323 001 311 301
303 146 002 000 000 000 041 011 002 346 177 303 354 001 026 000
315 052 001 303 040 001 310 376 012 310 024 311 315 276 000 021
000 000 303 346 001 000 000 000 000 000 000 000 000 000 000 000
```

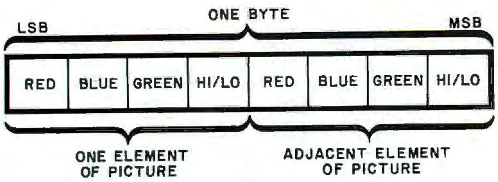


Fig. 5. In low-resolution mode, four bits of computer memory are used for each picture element.

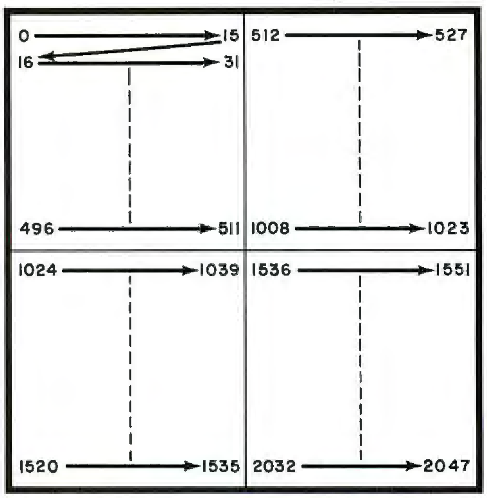


Fig. 6. Memory map of the Dazzler picture. Only first quadrant is displayed in the 512-byte display. All four are displayed in 2K-byte picture.

the component side of one facing the soldered side of the other. The two are separated by exactly the same distance as two adjacent connectors on the Altair bus.

Check-Out. Check for solder bridges and proper component orientation. Facing the component side of a board, pin 1 of each IC should be at the lower left. Check the interconnections between the boards.

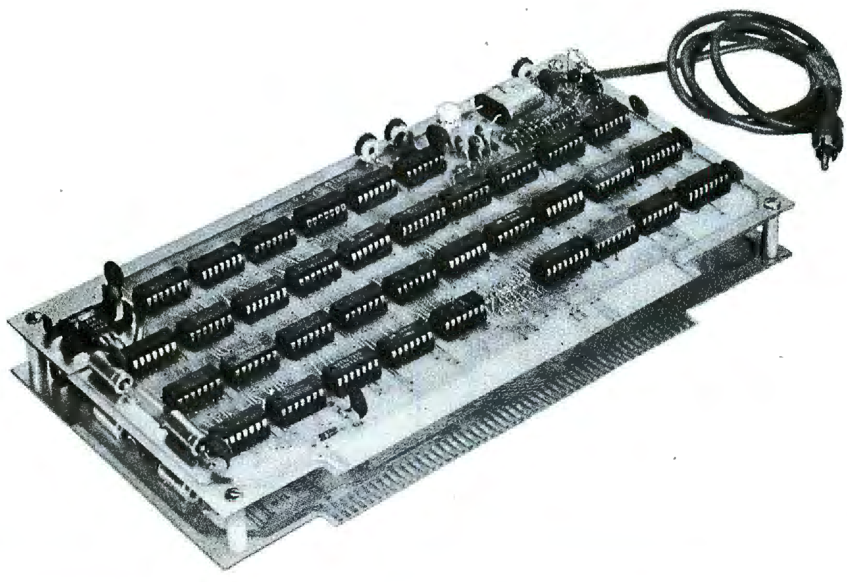
Turn off the power to the Altair and then insert the Dazzler into adjacent sockets on the bus line. Using a length of coaxial cable, connect the Dazzler video output (ground the coax braid to the adjacent ground foil) to the video input and signal ground of your color TV receiver. The connection can usually be made at the input to the video amplifier, with a switch to select the normal input or the Dazzler input.

Tune-Up. The Dazzler is activated and deactivated by software control. The simple program shown in Fig. 4 will turn the Dazzler on and display a picture that is stored starting at location zero in memory (D0 through D6 of output port 016 at zero). This short program also allows sense switch control of the word sent to output port 017. The sense switches are labelled *A8* through *A15* on the front panel of the Altair.

Load from the program in Fig. 4 into the Altair from the front panel, examine zero and run the program beginning at location zero in memory. (Be sure all sense switches are down.)

With the color TV set operating and the Altair "running", raise sense switch *A12* and note that a colorful quilt-like pattern appears on the screen. Potentiometer *R30* (bias) on board 1 of the Dazzler acts as a horizontal hold control and should be adjusted to obtain a stable picture.

Raise sense switches *A10* and *A11*, and adjust capacitor *C17* on board #1 for the most saturated blue on the screen. Now put *A10* down, raise *A9*, and adjust *R32* for the most saturated green color. Finally, set *A9* down, raise *A8*, and adjust *R32* for the most saturated red color.



The Dazzler fits in two slots on the Altair bus. Output is video and can be fed to amplifier of TV set or an FCC-approved class-1 r-f device.

Dazzler Software. When writing programs for the Dazzler, it is important to remember that the TV picture is stored as a specially coded sequence in the computer memory. The Dazzler simply interprets this code to form the TV image.

Two different codes are used depending on whether the Dazzler is in the low-resolution or high-resolution mode. This is determined by the control word at output port 017. In the low-resolution mode, four bits of computer memory are used to code each element of the picture (Fig. 5). Either a 32 x 32 or 64 x 64 element picture can be displayed. The latter is organized as quadrants within the computer memory as shown in Fig. 6.

In the high-resolution mode, each bit of memory is used either to turn on (bit=1) or off (bit=0) a single memory element. The control word output to port 017 is used to set the picture color. Figure 7 shows how one byte of memory is divided up to control eight elements of the picture. In this mode, either a 64 x 64 element picture using 512 bytes or a 128 x 128 element picture using 2K bytes can be displayed on the screen. ◈

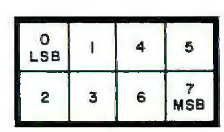


Fig. 7. In high-resolution mode, each memory byte is used to represent 8 picture elements.

THE NEW 1976 COLOR TV RECEIVERS

COLOR TV RECEIVER CHECK LIST

- ☐ Negative guard band picture tube
- ☐ Automatic frequency control (afc) or automatic fine tuning (aft)
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- ☐ Preset tint
- ☐ Preset brightness
- ☐ Preset contrast
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- ☐ Automatic voltage regulator (AVR)
- ☐ Automatic degaussing coil (ADC)
- ☐ Automatic color killer control (AKC)
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- ☐ 100% solid-state (except picture tube) chassis
- ☐ Instant on or quick on
- ☐ Modular construction
- ☐ Audio earphone jack
- ☐ 300- & 75-ohm antenna inputs

Serviceability and automatic color controls are emphasized in most lines.

BY ART MARGOLIS

The RCA line of XL-100 receivers features ColorTrak, a remote Control Center which operates all primary controls.

In the 30 years since television first became a serious entertainment medium, TV receiver design has come full circle. Some TV receivers started out in modular form and now most of them have come back to this practical method of assembly, prompted mainly by a need for simple, efficient servicing. High on the list of desirable features for modern TV receivers are modular circuit assemblies, featuring, in many cases, active components that plug in and out for easy replacement.

Just as the auto industry has become accustomed to introducing new model cars each year, TV receiver manufacturers think in the same terms. Each year sees new features incorporated into existing models and completely new models coming on the market. An example of the former is

the constant refinements in picture tuning systems to make them as automatic as possible. The latest systems automatically adjust most picture parameters (brightness, contrast, color, and tint) with the press of a button.

Here are some details of what the major color TV receiver manufacturers are offering for 1976.

Semi-toroid deflection yoke is used in Quasar's QMX-1 self-converging system to improve efficiency and reduce weight.

Zenith. A vertical chassis that contains a number of Dura-Modules® has been introduced by Zenith. The modules carry about 75% of the receiver circuitry. In addition, many of the IC's and transistors on the modules are plug-ins for easy replacement when only the device and not the entire module needs to be replaced.

Zenith's hot new item is a zoom feature that blows up the action at the center of the screen for a close-up view. You press a button on the hand-held Space Commander 1000 remote control transmitter, and the center-screen action blows up by 50%. (The zoom feature is accomplished by overscanning during beam deflection.) When the zoom is on, an indicator on the receiver lights up. When you press the ZOOM button on the remote control transmitter again, the picture returns to normal and the indicator extinguishes.

The electronic Space Commander 1000 remote control transmitter is a "first" for Zenith. In the past, Zenith's remote-control transmitters used mechanical ultrasonic transducers.

The Magnavox STAR system provides random-access, one-button tuning.

When the ZOOM button is pressed on Zenith's Space Command remote control models, the picture is enlarged 50%.

GTE Sylvania. GT-Matic™ tuning is featured in the new line of color TV receivers from Sylvania. Automatic adjustments are built in to cure problems involving the horizontal line, a rolling picture, poor contrast, lack of color, and incorrect tint. Since almost everything is automatic, the front panel of the Sylvania receiver contains only three controls: a combined power on/off and volume control and the vhf and uhf channel selectors.

The GT-Matic system is preset at the factory for a "normal" optimized picture. If you don't like what you see, a key provided with the receiver can be used to open a hidden panel to provide access to the BRIGHTNESS, CONTRAST, COLOR INTENSITY, and TINT controls. You can set these controls as desired and then lock the panel to keep others from disturbing the picture settings.

An afc circuit keeps the tuner from drifting off frequency, while a Perma Tint circuit acts as a monitor to maintain correct color levels. When the Perma Tint circuit is activated, the demodulation angle between the B−Y and R−Y signals is increased to provide a wider range of phase angles for determining the actual color of the flesh tones.

The usual vertical-hold control has been replaced with a vertical countdown IC. In the past, the vertical countdown circuit required too many components. However, in IC form, the

COLOR TV RECEIVER HIGHLIGHTS FOR 1976				
Company	**Chassis Series**	**Type of Tuner**	**Channel Indicator**	**Special Features**
Zenith	GC	Varactor	Digital	Zoom (enlarges center-screen action)
Sylvania	GT-Matic	Varactor	Digital	Key-locked picture control panel
Sony	KV	Detent	Tuner dial	Optional accessories
Sharp	C	Varactor & Detent	Digital & Tuner dial	Flat contacts on tuner for longer life
RCA	CTC 68	Varactor	Digital	ColorTrak automatic color control
Quasar	QXM-1 & QS 3000	Detent	Digital	Slumber Sentry (automatic shut-off); Power Saver switch
Philco	BOSS	Detent	Tuner dial	Power Guard for greater reliability and longer life
Panasonic	CT552 & GP-3000	Detent	Tuner dial	Mini color TV receiver with 4½″ picture tube
Magnavox	STAR	Varactor	Digital	On-screen channel numbers; STAR control panel on receiver
Hitachi	CT & CB	Detent	Tuner dial	Extra Strong warranty
GE	MB-2,MC-2, YA & YC	Varactor	Digital	
Admiral	M25	Detent	Tuner dial	

circuit is practicable and the picture is locked in even when there are noise pulses that would knock the vertical out of sync with ordinary vertical-hold circuits.

The Sylvania receivers also contain circuits that deal with airplane flutter, line voltage variations, and even transmitter-caused problems. Another circuit automatically adjusts the horizontal hold to maintain a stable picture.

Sylvania uses a modular chassis approach that features plug-in transistors in practically all circuits.

Sony. This company is progressing with its line of high-quality table-model color TV receivers. The CRT sizes keep getting larger and the 19″ (48.3-cm) Trinitron picture tube features a single cathode. It has a 114° deflection angle, which permits the receiver cabinet to have a depth of only 15⅝″ (40 cm). The shorter neck of the tube also diminishes the distance electrons have to travel from the "gun" to the screen, which means an increase in picture brightness.

Service consideration is a major Sony goal. Much time and money have been spent in documenting service notes, and the service manual for each TV receiver model is complete and well illustrated.

All kinds of optional accessories for portable receivers are offered by Sony. They include car battery cords, sun glare filters, rechargeable battery packs, earphones, and mobile, boat, and home antennas.

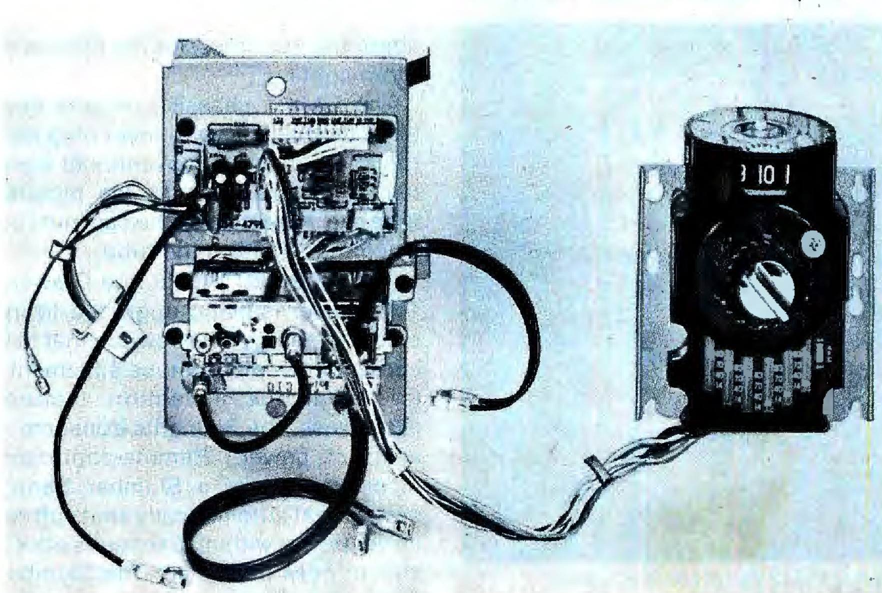
Sharp. The Sharp Linytron-Plus in-line, one-gun picture tube is being aggressively promoted. It has good overall performance characteristics.

The detented vhf turner has a feature that Sharp claims reduces wear and tear to provide longer life. Instead of using the traditional hemispherical contacts, they are flat so that, as the tuner knob is rotated, the contacts on the tuner "turret" press against flat stationary contacts. The electrical connections cover a much larger area than the point-contact hemispherical contacts.

The Linytron picture tube is equipped with a fast-start heater. When the receiver is turned on from a cold start, you get sound instantly, followed four seconds later by the picture.

An LDR gives the Sharp receivers an "Optimatic" light-sensing feature that serves as an automatic brightness-level control system. There are a number of remote-control receiver models in the company's line, plus a 12-pushbutton variable-capacitance (Varactor) tuner model that eliminates moving parts.

RCA. This year, RCA is continuing to market its XL-100 series of color TV



No moving parts are used in Zenith's 18-position tuning system. Vhf is set at factory with six positions for customer tuning of uhf.

receiver chassis. The XL-100 is 100% solid-state, and the bottom-of-the-line hybrid (tube/transistor) receivers have been phased out.

Ten of the XL-100 receivers (19" and 25" diagonal) now have a color control system called ColorTrak which relies on a new solid-state chassis and a new picture tube employing filtered phosphors. The latter are said to reduce the reflection from ambient light, producing clearer blacks and more vivid colors. XL-100 consoles with ColorTrak also have a new remote Control Center which operates all of the primary controls and provides for display of the time of day and channel number on the screen.

More wood (less plastic) is emphasized in the 1976 line, which includes five main screen sizes: 15", 17", 19", 21", and 25" (38, 43.2, 48.3, 53.3, and 63.5 cm), measured diagonally. The 21" and 25" models have CTC68 chassis and 31-kV high-voltage power supplies.

RCA also concentrates on ease of servicing. Twelve small plug-in modules and five IC's are used in the circuit design. The modules are upgraded as repetitive field troubles are discovered. For instance, if a particular transistor repeatedly fails in the field, its circuit is redesigned to correct the condition. Care is taken to keep the same plug contacts on the modules during upgrading.

With 12 modules in the receiver, each module's cost is relatively lower than a receiver in which fewer modules are used. Thus, the value of a module approaches a throw-away status which greatly simplifies servicing.

In Quasar color control, room brightness is sensed by an LDR behind honeycomb lens. Picture power is adjusted automatically.

Low power consumption is a continuing RCA aim, and the company claims that its new console receivers require some 48% less power than comparable tube-type receivers.

Quasar. Quasar is now owned by Matsushita, which also produces the Panasonic line of TV receivers. However, the two brands are produced by independent operations.

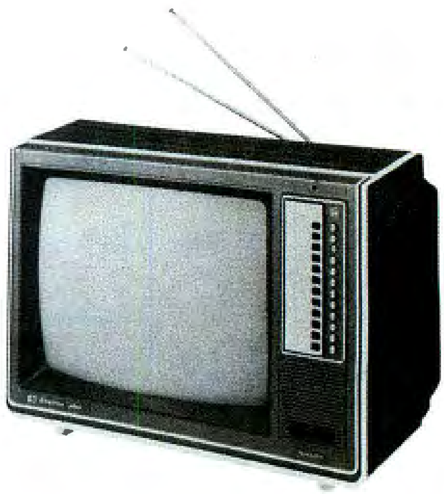
A new QMX-1 color TV receiver chassis is featured in the 13" and 15" (35 and 38 cm) models. This is not a "works in a drawer" chassis. It has an in-line picture tube with a semi-toroid yoke, which eliminates the need for dynamic convergence adjustments, though static convergence, purity, and gray-scale adjustments must still be performed. No dot/crosshatch generator is needed for making the required adjustments. The service technician who sets up the receiver can "eyeball" all color adjustments, which reduces the cost of the service bill.

Quasar is using the Panasonic Quintrix in-line black-matrix picture tube in its chassis. The tube has an extra prefocus electrode for sharper pictures. Since the deflection yoke is not cemented to the neck of the tube, if the yoke fails, only it has to be replaced, not the entire assembly.

Quasar places a lot of emphasis on its Super Insta-Matic automatic brightness control feature. In essence, this system uses an LDR circuit to adapt the brightness of the picture to room lighting.

The QMX-1 chassis contains only three modules. Two of them plug into the chassis in the conventional manner. The third includes the picture-tube cap; to remove it, the cap must be disconnected from the tube.

The QS 3000 "Works in a Drawer" TV receiver is being upgraded to include an energy-saver switch that disconnects the picture tube's filaments to defeat the instant-on feature. (Otherwise, the filaments consume 4 watts of power.) Remote-controlled receivers feature a Slumber Sentry system that automatically shuts off receiver power within 20 seconds after a station goes off the air. The Slumber Sentry detects the absence of vertical sync pulses to trigger the shut-off mechanism.



Sharp's 19" model has 12-button Varactor tuner with one-button color tuning system. Solid-state modular chassis are used.

Philco. Until recently owned by the Ford Motor Company, Philco is now a part of GTE Sylvania. However, the Sylvania and Philco TV receiver divisions are autonomous.

The 1976 color TV receiver line from Philco contains four portable and 10 large-screen models. In the portable lineup are one 19", two 17", and one 15" receivers. Each features an all solid-state BOSS chassis, Philco's Automatic Lock Channel Tuning (ACT), 70-position click-stop uhf tuner, in-line picture tube, and plug-in transistors for ease of servicing.

All large-screen Philco receivers have 25" black matrix picture tubes. There are seven consoles, one table model, and two home-entertainment center receivers in the line. (The home entertainment centers are color receiver and stereo system combinations.) Each large-screen receiver has the same features as the portables, plus modular chassis, lighted channel indicators, and the Philco Power-Guard System that provides improved reliability and longer chassis life.

Panasonic. New to the Panasonic line this year is the 4½" (11.4-cm) diagonal-measurement Model CT-552 color TV receiver. Not a toy, this sophisticated receiver has Panasonic's Q-Lock II automatic tint and color circuit and a tube that gives pictures in 4 seconds. It retails for about $480. The circuit design is all solid-state and employs several IC's. The receiver can be line-powered or operated from a car or boat (12-volt dc) electrical system or its own re-

TYPICAL ENERGY USE vs WEIGHT FOR SOLID-STATE COLOR TV RECEIVERS

Screen Size	Power Consumption (watts)	Receiver Weight (in pounds)
4"	25	15
9"	60	25
13"	85	40
15"	85	50
17"	95	55
19"	100	65
21"	110	120
25"	130	135

chargeable battery pack. When powered from the ac line, it consumes only 22 watts. The receiver even has a system that automatically switches over to its internal battery pack should ac line power fail. Available accessories include earphones, rechargeable batteries, and glare-proof tinted screen.

There are also two new Panacolor receiver models available, measuring 12" and 19" diagonally. Both use the Quintrix picture tube and a new GP-3000 chassis. The number of components on the chassis has been cut by a full third when compared to previous models. The total wiring length has also been reduced from 46' to only 14'.

Power consumption is down in the Panasonic TV receivers. The high-voltage level in the 12" model is 24.5 kV, with power consumption at 103 watts. The 19" model requires 30 kV from the high-voltage supply and consumes 120 watts of power.

Magnavox. Last year, Magnavox made a big splash with its STAR (Selective Tuning At Random) remote-control tuning in its top-of-the-line receivers. This year, the STAR system is appearing in lower-priced large-screen and some 19" receivers as well. (STAR permits instant precision selection of any one of the 82 vhf and uhf channels at random and out of sequence. The system goes directly to the selected channel without having to cycle through a lot of intermediate channels.)

Last year's 15-button STAR control panel was available on only the hand-held remote control transmitter. This year, it's also on the TV receiver.

With the STAR system, when a channel is selected; its number is displayed in 5" (12.7-cm) high numerals at the top of the picture. The numerals are displayed for about three seconds, after which they blank out. The system never needs fine tuning.

Magnavox is attempting to provide high-fidelity sound from its receivers. To this end, larger than average dual-cone 9" (22.7-cm) speakers, separate transducers, and speaker pairing are used.

Hitachi. Although it is primarily in the portable TV business, Hitachi also has a consolette with a 21" diagonal measurement picture tube. Hitachi receivers start with a 9" model that operates on ac line power or from a 12-volt dc car/boat electrical system. Also in the line are 13", 15", 17", and 19" portable TV receivers.

The Hitachi TV system is called SMAGC, which stands for Seven-Merit Automatic Gain Control. One of the seven merits, APS (Automatic Picture Setting), performs the usual preset control functions for color, tint, brightness, and contrast. However, it is combined with a tint stabilizer and the Automatic Color Control (ACC) to maintain correct tint and color intensity when changing channels or when a camera switch is made during a program.

Hitachi has an "Extra Strong" warranty. It covers transistors for 10 years and all other parts, including the picture tube, for two years.

Portable model from Panasonic has a 4½" diagonal screen.

GE. Three basic types of chassis are in the GE color TV receiver line for 1976. The large-screen MB-2 and MC-2 chassis in color consoles have 25" picture tubes. These are the latest version of the MB chassis introduced a year ago. The YA chassis, also a holdover from last year, is supplemented by the new YC chassis used in the 13", 17", and 19" color TV receivers. Small-screen models continue to use GE's 10HE chassis.

The only major design change in the GE receivers is in the modular M series. Last year, the high voltage was produced by a 7.5-kV flyback transformer and quadrupler rectifier that brought it up to 30 kV. This year, the flyback circuit develops about 10 kV, while a tripler rectifier is used to do the boosting to the required 30 kV.

The GE modules continue to undergo constant updating. For instance, the chroma and vertical modules have been changed but inputs, outputs, and plug-pin configurations remain the same.

The YC chassis has a 29.5-kV supply (higher than that used in the older YA chassis) and top and bottom pincushion correction circuits.

A caddy-size symptom/repair manual is available for recent GE chassis. Each trouble symptom is listed with a "most likely cause."

Admiral. In Admiral's IM30 chassis, the power transformer has stable voltage regulation. The ac line voltage can vary from about 90 to 130 volts without seriously affecting the picture. The power transformer is tuned to the 60-Hz line by a 3.5-μF filter capacitor across its secondary. The inductance of the secondary combines with the capacitor to form a tuned LC system.

The transformer is wound in a special configuration so that the tuned secondary produces fixed-amplitude square waves, with the transformer operated in saturation. When the input is 117 volts ac, the output is clipped to a square wave of fixed amplitude. As the line voltage varies, any changes produce inverse changes in the clipping action. The voltage output level, however, remains the same.

Summing Up. Color TV receivers of all makes are reaching a high state of excellence. They are capable of producing near-perfect pictures, lasting longer, and requiring less service than previous models. ◈

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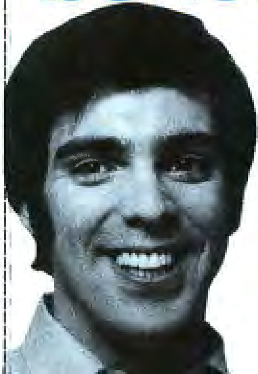

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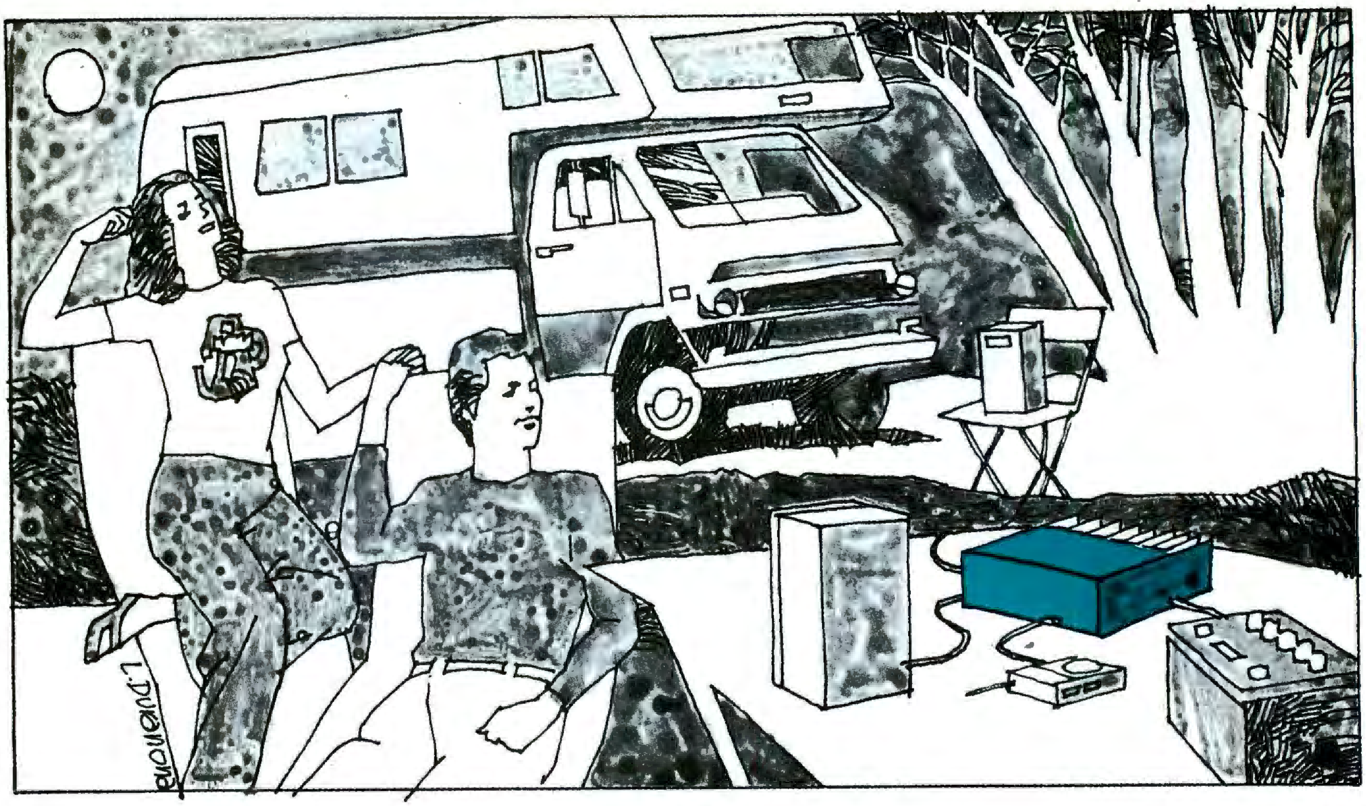

CONSTRUCTION

A HIGH-POWER MOBILE STEREO AMPLIFIER

Provides clean, 15-W/channel audio from a 12-V dc source.

BY EDGAR BRADEN

TRYING to get high-fidelity sound in a mobile environment presents very difficult problems. First of all, ambient (road and motor) noise must be overcome. But the direct-coupled, complementary output stages of many tape players and radios cannot produce more than a few watts of power. Output transformers could boost the power, but serious drawbacks such as bulkiness and high cost make them impractical.

In the face of these limitations, many camper, sports car, and boat owners still ask, "How can I get an appreciable amount of clean audio output using solid-state circuitry operating from a +12-V dc source?" This article provides the answer with the Mobile Stereo Power Amplifier.

The amplifier will provide 15 W rms/channel of low-distortion audio into 8-ohm loads (enough to drive even low-efficiency speakers). Only a +12-volt dc supply is required, and with slight modifications, it will operate from 6-volt supplies. Also, the amplifier sections for the two channels can be "bridged" (driven out of phase) to provide 30 watts monaural into a 16-ohm speaker, or paralleled for a 4-ohm load. Parts cost for the amplifier is about $25. Of course, two such units can be operated independently in the bridged or parallel mode to provide 30 watts per channel for stereo.

Among the amplifier's features are direct-coupled output circuitry, a high-frequency (20,000-Hz) dc-to-dc converter, and a low-distortion IC audio driver. The converter offers high efficiency and compact size as a result of its operating frequency. What's more, core (magnetostriction) and pickup noise lie beyond the audible spectrum. Above all, both the power converter and audio amplifier are easy to build!

About the Circuit. The dc-to-dc converter shown in Fig. 1 is a fairly standard design. Its frequency of operation is governed by saturating-core transformer *T1*. The winding (points 5 and 6) connected to the bases of transistors *Q3* and *Q4* is phased to provide positive feedback, which sustains oscillations. Thus a 12-volt, 20,000-Hz square wave is applied to the primary

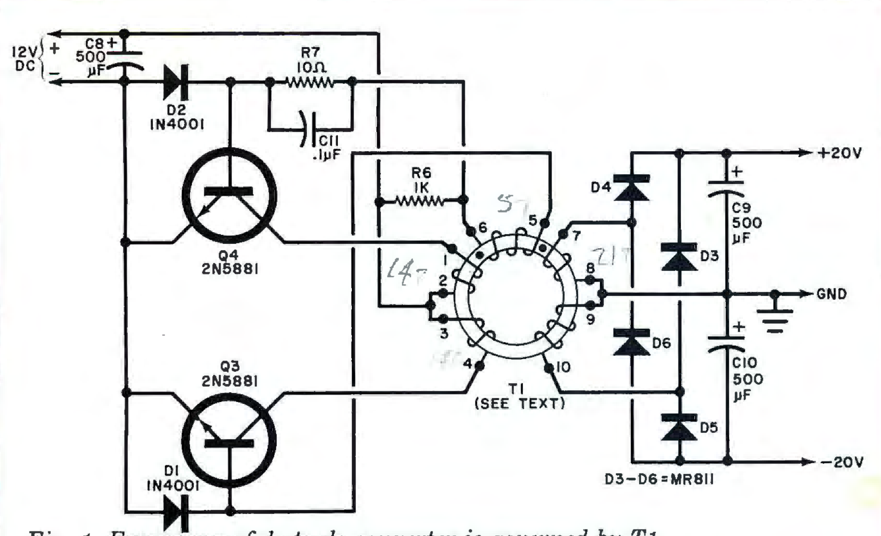

Fig. 1. Frequency of dc-to-dc converter is governed by T1.

POWER SUPPLY PARTS LIST

C8,C9,C10—500-µF, 25-volt electrolytic capacitor
C11—0.1-µF paper or Mylar capacitor
D1,D2—1N4001 rectifier
D3 through D6—MR811 (Motorola) or 1N4933 fast-recovery diodes. (See the text)
F2—10-ampere slow-blow fuse
Q3,Q4—2N5881 (Motorola) npn power transistor—(do not substitute)
R7—10-ohm, 2-watt resistor
R6—1000-ohm, ½-watt resistor
S1—Spst switch
T1—See text. Requires a Ferroxcube No. 846T250-3E2A toroid core.
Note: an etched and drilled circuit board is available from EBCO, 10 Sherwood Drive, Nashua, NH 03060 for $4.50. The Ferroxcube toroidal core is available from Elna Ferrite Laboratories, Inc., Box 395, Woodstock, NY 12498, for $1.75 (first class postage paid).

of *T1* (points 1 and 4) via the collector leads. The stepped-up output of *T1* is rectified by the full-wave bridge *D3-D6* and filtered by *C9* and *C10*. A bipolar (±20 V, referenced to ground) output is obtained.

A ferrite toroid is used as the core of *T1* because of its high permeability and residual magnetization (remanence), which aids the switching between the transistors. Further, the toroid's form factor keeps core losses low as there is a minimum of magnetic material for a large power-handling capability. Toroids are self shielding—all magnetic flux remains in the core. This isolates the switching circuit from the power amplifier. Also, fewer turns are required, so heavier gauge wire can be used, resulting in lower I^2R losses. And, practically speaking, the toroid is much easier to wind by hand than the bobbin of a laminated-iron core!

A Signetics NE540 integrated circuit acts as the power amplifier's input stage and supplies base drive to power transistors *Q1* and *Q2*, which form a complementary-symmetry output stage (Fig. 2). It also controls the transistors' bias current to minimize crossover distortion.

The 540 IC is a high-fidelity device, having a bandwidth exceeding 100,000 Hz. Its output stage can drive a 600-ohm load to 3 dB below maximum, with a typical distortion figure of 0.5% at 40 dB gain. The circuit configuration shown in Fig 2 has a gain of 34 dB, which should reduce distortion to about 0.25% for high-fidelity listening. Note that only one channel (Channel A) is shown.

Construction. The task of winding *T1* is not really difficult, but care must be exercised to keep track of the start and finish ends of each winding to assure proper phasing so the circuit will oscillate.

Use No. 20 enameled magnet wire for both the primary and secondary windings. (No. 22 wire can be substituted.) Fold in half a 5′ (1.52-m) length of the wire and wind this around the toroid for a total of 14 turns. Distribute the wire as evenly as possible all the way around the core. Bend the wire sharply around the corners of the core to make tight windings. When you are finished, label the two free ends with pieces of tape numbered 1 and 3. Snip through the fold loop. Then use an ohmmeter to determine which of the newly cut ends has continuity with lead 1; label the unmarked end lead 2. Then label the remaining unmarked lead with a 4. (It should have continuity with lead 3).

Next, wind the feedback winding. This consists of five turns of No. 22 or No. 24 wire, evenly distributed around the core. Start and finish the winding

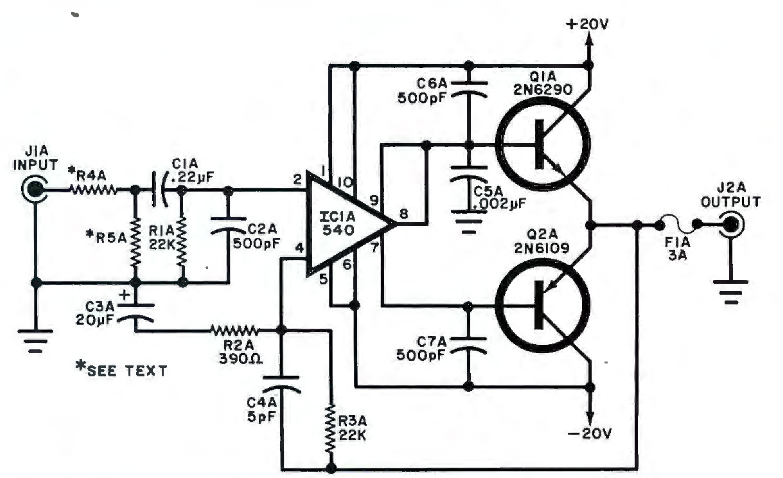

Fig. 2. First stage of amplifier is an integrated circuit.

AMPLIFIER PARTS LIST

C1—0.22-µF Mylar capacitor
C2,C6,C7—500-pF disc capacitor
C3—20-µF, 15-volt electrolytic capacitor
C4—5-pF silver mica or ceramic capacitor
C5—2000-pF (0.002-µF) disc capacitor
F1—3-ampere fast-blow fuse
IC1—NE540 or SE540 integrated circuit (see text)
J1,J2—Phono jack
Q1—2N6290 npn power transistor
Q2—2N6109 pnp power transistor
R1,R3—22,000-ohm, ½-watt resistor
R2—390-ohm, ½-watt resistor
RA,RB—Input attenuator resistors (see text).
Misc.—Printed circuit board; fuse holders (3); heat sink or chassis box; 22,000-ohm, ½-watt resistor for bridge hookup (see text); spacers (4); mica and plastic-film insulators for transistors; silicone heat sink paste; magnet wire for T1; silicone adhesive; machine hardware; hookup wire; solder; etc.

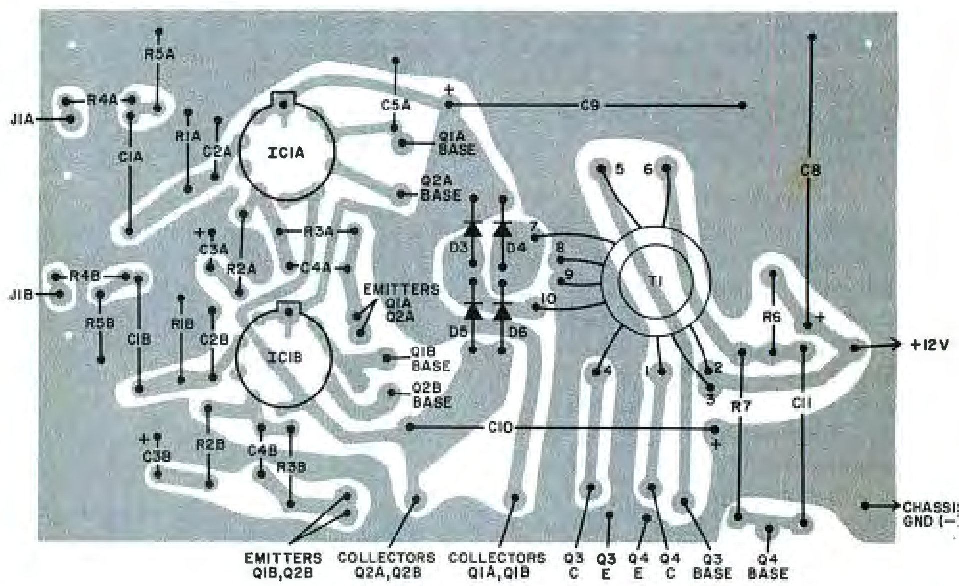

Fig. 3. Actual-size etching and drilling guide for pc board is shown above with component layout at right.

on the opposite side of the core from the primary leads 1 and 4 to facilitate matching the leads with their pads on the pc board. Label the ends of the feedback winding 5 and 6, taking careful note that current flowing *from* 5 *to* 6 should pass through the hole in the core in the same direction as current flowing *from* 1 *to* 2 or *from* 3 *to* 4 in the primary winding.

The secondary winding comes next. As with the primary, the secondary must be bifilar wound to provide tight coupling between the two halves of the winding. It also makes the job of winding easier. Fold in half a 6′ (1.83-m) length of No. 20 or No. 22 enameled magnet wire and wind 21 turns of the double strand around the core. Evenly distribute the turns around the core and press them tightly around the edges to allow sufficient room within the core's hole for the entire winding. When all 21 turns are on the core, label the two free ends 7 and 9. Cut the loop and, using an ohmmeter, pair up the wire that terminates with 7 and label it lead 8. Label the remaining unmarked lead 10. The direction in which the secondary is wound is not important.

(Note: For 6-volt electrical systems, reduce the number of primary windings to seven bifilar turns and the feedback winding to three turns.)

An actual-size etching and drilling guide for the pc board is shown in Fig. 3. After preparing the board, proceed with circuit assembly. Start by mounting *T1* in place as shown in the component guide (also shown in Fig 3.). Do not forget to remove the enamel coating on the ends of the leads so they can be soldered to the copper pads on the circuit board. The leads will normally hold the transformer solidly against the top of the board, but it's a good idea to use a dab of silicone adhesive between board and transformer since the project will be subjected to vibration and other stresses. Taking care to observe polarities and IC pin basing, mount and solder into place the remaining components.

All transistors must be mounted on a heat sink that has at least 10 sq in. (6.54 sq cm) of radiating area. Standard 1/16″ (1.6-mm) thick aluminum plate will do for the 15-W/channel stereo version of the amplifier if cut to

the same size as the pc board. After machining the heat sink, mount the transistors, using mica or plastic film insulators, silicone heat-sink compound, and insulating shoulder washers under the mounting screws for the board.

Solder *C6* and *C7* directly to the leads of transistors *Q1* and *Q2*, respectively. Similarly, solder diodes *D1* and *D2* directly to the leads of transistors *Q3* and *Q4*, respectively. Or, if preferred, the capacitors and diodes can be soldered to the appropriate pads on the foil side of the pc board. When this is done, solder interconnecting hookup wire between the transistor leads and the appropriate points on the pc board.

Now, using ¾" to 1" (19-25.4-cm) spacers and machine hardware, sandwich the pc board and heat-sink assemblies together. The transistors must be on the side of the aluminum plate that is opposite the pc board to provide shielding between the transistors and amplifier inputs.

If desired, connect an SPST switch (*S1*) in series between the +12-volt supply and the appropriate pad on the pc board. However, the vehicle's ignition switch can be used in place of *S1*. It is also advisable to insert *F2*, a 10-ampere, slow-blow fuse between the supply and *S1*.

If you plan to use a box to house the amplifier, select one that measures 6"L × 4"W × 1½"D (15 × 10 × 3.8 cm). Mount the transistors on the top of the box, cases outward and secure the circuit board assembly with spacers and machine hardware. Don't forget to mount the fuse blocks where they will be easily accessible. When you mount the project inside your vehicle, bear in mind that the transistor cases are electrically "hot." So, take care that they do not short out against the project or vehicle chassis. Insulate them with a layer of electrical tape or a cardboard shield. Note that we assume a negative-ground 12-volt source. A positive-ground supply can also be used, but make sure that the amplifier pc board "ground" is not connected to the vehicle's chassis ground.

A word about rectifiers *D3* through *D6* is in order here. These are MR811, fast-recovery devices. If you expect full sustained output power from the amplifier, *do not substitute devices.* Power supply transistors *Q3* and *Q4* must be high-frequency devices with an f_T of at least 4 MHz. They should have a beta of at least 20 at 6-A collector current. Lower frequency transistors have a tendency to overheat at the switching frequency employed.

Getting More Power. The amplifier can provide 30 watts of output power into a *monaural* load for 4- or 16-ohm speakers. For 4-ohm speakers, simply parallel the inputs and outputs. For 16-ohm speakers, a bridge configuration can be used as shown in the simplified schematic of Fig 4. Note that a 22,000-ohm resistor must be connected from pin 4 of the channel B driver IC to the junction of *C4* and *R3* in the channel A circuit. Also, channel B's input must be grounded at the input jack *J1B*. Connect a 16-ohm speaker directly across the "hot" sides of jacks *J2* of both channels.

With the system wired as shown in Fig. 4., the second amplifier channel is driven out-of-phase with the *IC1* channel. This doubles the voltage across the speaker load, and thus

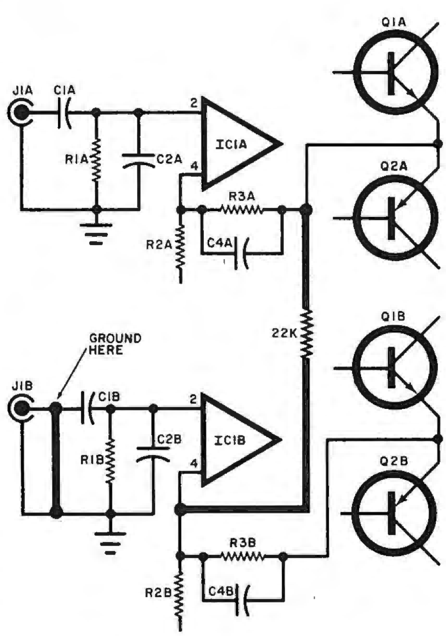

Fig. 4. Additional connection shown in bold will drive the amplifier, in bridged mode, giving 30 W rms (monaural) into 16 ohms.

quadruples the power into the load. However, the output transistors cannot handle this much power. By doubling the load impedance to 16 ohms, however, power is merely doubled to 30 watts. This is well within the power rating of the audio transistors.

Output power from each channel in this OTL (output-transformerless) circuit is limited by the maximum supply potential rating of ±22 volts for the NE540 IC. However, if you can obtain the SE540 version of this IC, you can raise the clipping power level by about 15%. To do this, the supply voltage must be increased to ±27 volts by adding four turns to the secondary winding of *T1*.

Using the Amplifier. The low-level outputs of most tape decks and tuners can directly drive the amplifying system. However, if you tap the signal at the speaker output jack, the attenuator network consisting of *R4* and *R5* must be used on each input to reduce signal amplitude to a reasonable level. A good choice of values for *R4* and *R5* would be 10,000 and 1000 ohms, respectively. These values can be varied according to the output level of the tape player or radio used.

If the driving signal is taken from across a volume control, the attenuator network can be eliminated altogether. But if the attenuator is used in this situation, put a coupling capacitor in the input line to avoid placing too heavy a dc load on the source and to prevent upsetting bias levels.

The pc board for the amplifier (Fig. 2) has provisions for installing *R4* and *R5*. If you do not need the attenuator, connect the input line directly to one of the free holes on the board common with *C1*.

Because the amplifier uses feedback, it is possible that "parasitic" oscillations may occur at a few hundred kilohertz. Although they are inaudible, these oscillations can affect quiescent bias conditions, and thus increase distortion. If you suspect the amplifier is oscillating, install a suppressor (a single layer of No. 24 wire wrapped on a 10-ohm, 1-watt resistor) between the emitters of the complementary pair, *Q1* and *Q2*, and the fuseholder for F1. The suppressor will not affect *audio* response in any way.

Much ignition noise pickup can be eliminated by bolting the amplifier right to the radio receiver or vehicle chassis. This will also prevent ground-loop currents from getting into the amplifier; but it will probably not be necessary if a high-level input is fed to the attenuator network. When used with an AM receiver, the amplifier must be shielded or located several feet away from the receiver. Otherwise harmonics of the switching frequency of the power supply will get into the receiver's i-f section. ◈

BY FORREST M. MIMS

TALK OVER A SUNBEAM WITH A "PHOTOPHONE"

Modernized version of Alexander Graham Bell's sunlight communicator provides some 1880 electronics nostalgia—that works.

A LITTLE-KNOWN fact about the inventor of the telephone is that Alexander Graham Bell considered an electro-optical communicator he called a "Photophone" to be his greatest invention, greater even than his telephone. In 1880, Bell and Sumner Tainter communicated by voice over a beam of reflected sunlight. This was 19 years before A. Frederick Collins conducted the first feeble voice transmissions over a distance of three blocks in Narberth, Pennsylvania. So, the first "wireless" voice transmissions were *not* by radio, as history would have us believe.

Compared to the power-hungry radiotelephone medium developed 25 years after Bell's discovery, the Photophone was an elegantly simple technological marvel.

Bell and Tainter succeeded in developing more than 50 ways of voice-modulating a beam of light, including variable-polarization schemes used today in sophisticated laser communication systems.

Photophone Details. The simplest of Bell's and Tainter's modulators consisted of a small flat mirror cemented to a hollow cylinder. Voice energy directed into the open end of the cylinder caused the surface of the mirror to flex in step with the speech patterns. By shining a continuous beam of light onto the mirror's surface, a variable beam impressed with the voice modulation was produced.

Most of the light-beam receivers used with the Photophone employed selenium detectors. (In 1873, it was discovered that the resistance of bulk selenium changed in response to varying light intensity.) It was after Bell had read about selenium experiments that, in 1878, he conceived his Photophone idea.

One of Bell's detectors consisted of a circular array, while another consisted of a cylindrical array of selenium cells. The first was designed to be used with a collector lens, while the latter was designed to be used with a parabolic reflector. Both detectors were connected in series with a battery and a telephone receiver to make up the receiving equipment for the Photophone.

On April 1, 1880, Tainter voice-modulated a beam of sunlight from a mirror and talked to Bell over a 699-ft (213-m) range. After this, Bell made optimistic predictions about the future of his Photophone, none of which materialized during his lifetime. In fact, shortly after Bell's death, in 1921, the Photophone was used mainly in a few military applications. Bell was criticized and even mocked for his opinions and predictions. Today, as we are poised on the threshold of large-scale light-beam communication, the inventor has been vindicated. In short, his predictions after all these years are finally materializing.

Build a Photophone. Bell's sunlight communication experiments can easily be bettered and duplicated with modern solar cells and audio amplifier modules. You can start with Bell's simple mirror-and-cylinder transmitter. An excellent choice for this purpose is the $1.65 Cat. No. 30,626 mirror from Edmund Scientific Co. (300 Edscorp Bldg., Barrington, NJ 08007). This mirror measures 25 mm in diameter and nicely mates with a 1" (25.4-mm) diameter tube.

Cut the tube to a length of about 2" (50.8-mm). Then, use white glue to cement the mirror to one end of the tube. Make certain that the aluminized surface of the mirror is facing outward to obtain best results. (You can determine which is the mirror's aluminized surface by touching both surfaces with the point of a pencil and observing the reflections. The side that shows *no* gap between the real and image points is the aluminized surface of the mirror.) True, the uncoated surface of the mirror is more resistant to scratches and abrasion, but if this surface faced outward, 5% less light would be reflected, which means you would have a shorter communication range.

The Photophone receiver can be as simple as a single silicon solar cell connected across the input of an inexpensive audio amplifier module (see Fig. 1). Of course, the larger the active area of the cell the better the results.

A convenient housing for a basic receiver can be had by modifying a flashlight, such as the Burgess "Dolphin."

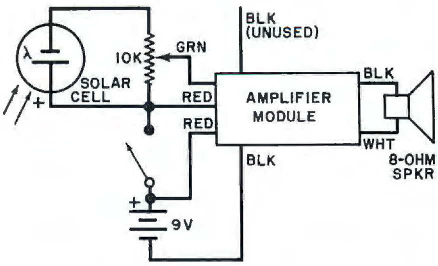

Fig. 1. Schematic diagram of a simple Photophone receiver.

This flashlight's built-in reflector is an ideal place for mounting a pair of solar cells because it would reflect far more light onto the cells than would be possible if the cells were used by themselves.

Mount two solar cells, back-to-back and connected in series with each other, by their leads with their plane lying along the axis of the reflector. Focus the detector by adjusting the mounting leads while observing their reflections. When the dark surfaces of the two cells fill the entire area in the reflection, the cell detector is properly aligned.

BILL OF MATERIALS

Transmitter:
1—25-mm diameter mirror (see text)
1—2"-3" length of 1" outer-diameter rigid tubing
White glue

Receiver
1—16" diameter parabolic mirror (see text)
1—Audio amplifier module (Radio Shack No. 277-1240 or similar)
1—Miniature 8-ohm loudspeaker
1—10,000-ohm potentiometer with spst switch
1—2 × 2-cm silicon solar cell
1—9-volt battery
1—Miniature phone plug and jack
1—17" × 17" piece of ½" plywood (rear panel)
2—17" × 3" pieces of ½" plywood (side panels)
2—16" × 3" pieces of ½" plywood (top and bottom panels)
2—3" lengths of ¾" × ¾" pine (cabinet feet)
2—3" × 1½" pieces of ½" plywood (door legs)
1—12" length of 1½" × ⅜" piece of hardwood lumber (detector arm)
1—3" length of 1½" × ⅜" piece of hardwood lumber (detector arm)
1—1½" length of 1½" × ⅜" piece of hardwood lumber (detector arm)
1—6" length of 1" × 1" pine (door-opener block and mirror retainers)
1—16" length of ¼"-diameter hardwood dowel (door opener and solar cell)
5—Metal hinges (doors and detector arm)
1—Drawer pull (cabinet handle)
1—Hasp and lock or hook and eye
Misc.—Flat black and white enamel paint; resilient foamed plastic; white glue; #6 machine hardware; 1" finishing nails; vinyl electrical tape; battery clip and battery holder; metal spacers (4); stranded hookup wire; solder; etc.

Getting Greater Range. The Photophone receiver described above will have a range of up to 550' (168 m). For really long-range communication by sunlight, you can use a large Fresnel lens or parabolic mirror to increase the optical gain of the receiver's detector. A 16" (40.2-cm) reflector—complete with detector, amplifier, battery, and loudspeaker —is shown in a plywood cabinet in Fig. 2. This receiver can pick up good-quality voice and music from as far away as a half mile. Increasing the transmitter's mirror as well, will increase the communication range even more.

You can duplicate this receiver by following the construction details given in Figs. 3 and 4. Make the cabinet from ½" (1.27-cm) thick plywood, but don't install the doors until later. Paint all inside surfaces of the cabinet flat black and all outside surfaces white enamel. The black in the interior reduces stray light reflections, while the white exterior makes for good visibility during alignment.

The 16" parabolic mirror is available from Edmund Scientific for $14.25 as Cat. No. 80,097. It is aluminized on its rear surface, which prevents it from being a perfect reflector. But its ½" circle of reflected light at the focal point is about the same size as the photocell, which at least partially makes up for the shortcoming.

Four wood retainers hold the mirror in place inside the cabinet. After cutting these retainers to size, use white glue to cement strips of resilient foamed plastic along one entire narrow face of each. Then, while the glue is setting, locate and drill the mounting holes for the retainers. By this time, the glue should have set. Paint each retainer block—not the foamed plastic—flat black and let them dry.

Meanwhile, mount a pair of pine legs on the bottom of the cabinet. Install the carrying handle on the top of the cabinet, and use white glue to cement a 1"-square piece of resilient foamed plastic in the center of the inside rear wall of the box.

Mount the hinges on the cabinet's doors. Carefully align the doors with the front edges of the side, top, and bottom panels, and mark the locations of the remaining hinge holes. Remove and set aside the doors and drill the holes at the points indicated.

Now, lifting the mirror only by its edges, carefully position it in the cabinet. Mount the four retainer blocks in place with their foamed surfaces against the mirror's edge. The foamed plastic should be lightly compressed, holding the mirror firmly but gently in place, when all four retainers are fastened down with machine hardware. Once the mirror is in place, exercise care when working around it. Always place a thick bath towel or a blanket over the mirror when you are working on the cabinet.

The detector used in this receiver should be a single 2 × 2-cm silicon solar cell mounted at the end of a hardwood dowel (see Fig. 4) that plugs into a two-section arm made from

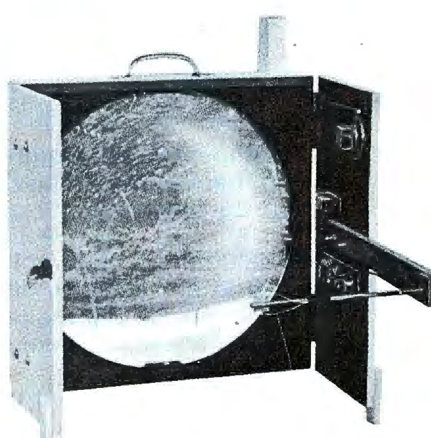

Fig. 2. This receiver can pick up good signals as far as ½ mile.

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hardwood stock and hinged at the joint. (The arm is in two sections so that it can be folded to permit the doors to close without obstruction.)

Strike a pencil line down the length of the long arm section, centering it on the wide side. Then strike cross lines 1" from one end, and three more lines spaced 1¼" (32 mm), 2" (51 mm), and 3¼" (83 mm) from the first cross line. At each line crossing, drill a 3/16" (4.76-mm) hole through the wood. Then use a router, coping saw, or wood chisel to remove all the wood between the first and second and third and fourth holes, making the slots only as wide as the diameter of the original holes.

Butt together the two arm pieces as shown and mount a small hinge at the joint. Use glue and finishing nails to mount a square wood block at the free end of the short arm section. Paint the entire arm assembly flat black. When the paint has dried, drill a hole through the block and arm section, connect 12" (30-cm) lengths of stranded hookup wire to the lugs of a miniature phone jack, and mount the jack in the hole.

After painting an 8¼" long by ¼" diameter (21 cm × 6.35 mm) hardwood dowel flat black and allowing it to dry, mount the 2 × 2-cm silicon solar cell at one end with white glue. Solder stranded hookup wires to the cell's contacts at one end, and connect and solder the free ends of the wires to the lugs on a miniature phone plug. Cut a groove in the side of the dowel to permit the plug's plastic cap to slide over the wire leads. Remove enough wood from the dowel at the end opposite the cell to permit it to be force-fitted into the end of the plug's cap. With a little care, the dowel will be locked into place when the cap is screwed onto the plug. Use black electrical tape to bind the wires to the dowel in a couple of places.

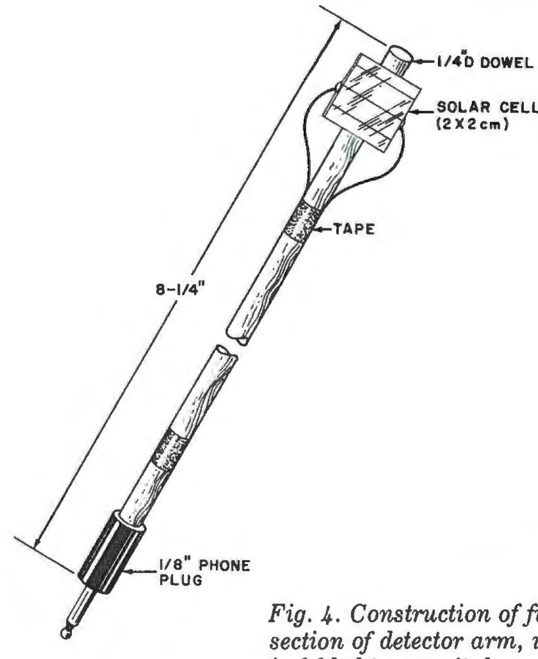


Fig. 4. Construction of final section of detector arm, which is folded to permit door closing.

Mount the dowel-and-block assembly that holds the door open at the top of the right door. Position it so that it will not interfere with door closure, and use glue and finishing nails, the latter driven through the door panel into the block. Make sure the nails do not interfere with free movement of the dowel and the dowel moves freely in the block.

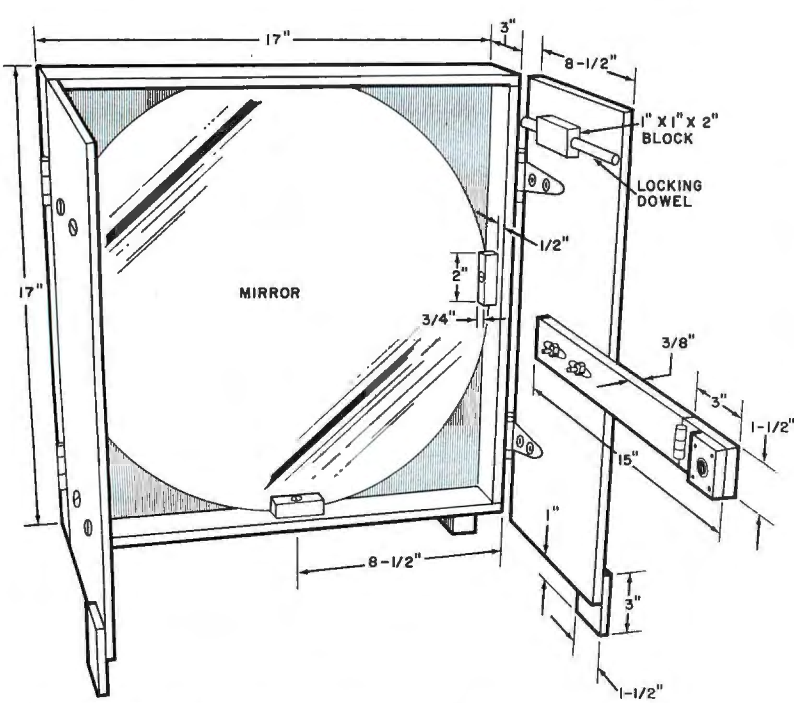


Fig. 3. Dimensions of the plywood cabinet for the Photophone. Mirror is held in place by wood blocks.

Locate and drill the holes for the detector arm as follows: First, strike a line across the panel midway between the top and bottom of the panel. Mount the door on the cabinet via its hinges. Slide the dowel in the block forward to lock the door open. Direct a strong beam of light on the mirror's surface. Now, plug the detector dowel assembly into the arm assembly and place the arm against the door panel. Center the slots in the arm over the line on the door. Standing out of the way of the light beam, move the arm closer to or farther from the mirror until the reflected light from the mirror just fills the detector cell's active surface area. Indicate on the door panel's line the points that mark the centers of the slots in the arm. Remove the arm, unplug the detector dowel assembly, and set both aside. Finally, drill a hole at each location indicated. Make the holes just large emough to require that you use a screwdriver to drive a pair of No. 6 × 1½" screws into the holes.

Remove the door panel from the cabinet. Mount plywood legs on the front of both door panels. Then paint the panels, flat black on their inside surfaces and white enamel on their outside surfaces. When the paint has thoroughly dried, drill perforations for the speaker grille, and mount the speaker on the inside of the panel. Use a metal L bracket for the switched potentiometer and spacers for the

amplifier module when mounting them in place. Then refer back to Fig. 1 and interconnect all components.

Anchor the detector arm to the door with large flat washers and wing nuts. (The wing nuts will facilitate easy focusing of the receiver during field operation.) Bolt the doors to the cabinet with No. 6 machine hardware. Use large flat washers under all screw heads and nuts. Finally, install a hook and eye or lock and hasp on the doors to keep them closed when the receiver is not in use.

Range Testing. Start your testing by fastening the transmitter mirror assembly directly over the speaker of a small portable radio receiver. Aim the beam from the transmitter down a range of several thousand feet where it will not be obstructed. Take the receiver several hundred feet downrange and align its mirror with the transmitter's reflected beam. Plug the detector dowel assembly into the arm on the door and adjust the focusing for the best possible received signal. With proper beam alignment and receiver focusing, you should be able to hear good-quality voice and music.

Continue to move the receiver away from the transmitter and make reception tests every 50′ (15 m) or 100′ (30 m) until the signal becomes too weak to "copy." Bear in mind that the earth's rotation will cause the sunlight reflected from the transmitter's mirror to move away from your original alignment point. So, you will occasionally have to adjust the transmitter's orientation to assure proper receiver/transmitter alignment. It helps if you can recruit one or two friends for the alignment procedure as distances can become quite great.

The maximum range of your system is dependent on the areas of the transmitter's and receiver's mirrors, overall gain of the receiver's amplifier, atmospheric condition, and angle of the sun in the sky. The last is of particular importance because high angles yield far more light intensity than do low angles. Offsetting this is the fact that at high angles, less of the transmitter's mirror surface is utilized that an the lower angles. Consequently, there is no way of predicting, with absolute assurance, what the range of your system will actually be.

Some Modifications. The Photophone can be modified in a number of ways to make it perform better. For example, you can increase sensitivity by using light shields and baffles to cut out extraneous light reflections, or you can use a preamplifier to boost the signal level from the solar cell. A large Fresnel lens can also considerably improve receiver operation. Edmund Scientific's No. 70,717 ($32.00) 24¾″ × 19¼″ (63 × 49 cm) lens has more than twice the collecting area and yields a smaller blur circle of light at its focus than does the 16″ mirror.

By using an amplifier module, microphone, and 49-mm-square mirror (Edmund Scientific No. 41,619 at $1.50 each) cemented to the cone of a 2″ miniature speaker with white glue, you can put together an excellent voice transmitter that will greatly increase the range of your system.

There are many more possible modifications you can use. With a little ingenuity, you can push the range of your system out to several miles. ◈

ELECTRONIC SWITCHING WITH TRANSMISSION GATES

CMOS device provides "bounceless" switching at speeds to 10 MHz.

BY ROBERT D. PASCOE

LOW-LEVEL analog or digital signals must often be switched between various circuits at high speed. In such cases, a simple electromechanical switch, such as a relay or reed switch, must generally be avoided because of the inherent contact bounce and long switching time.

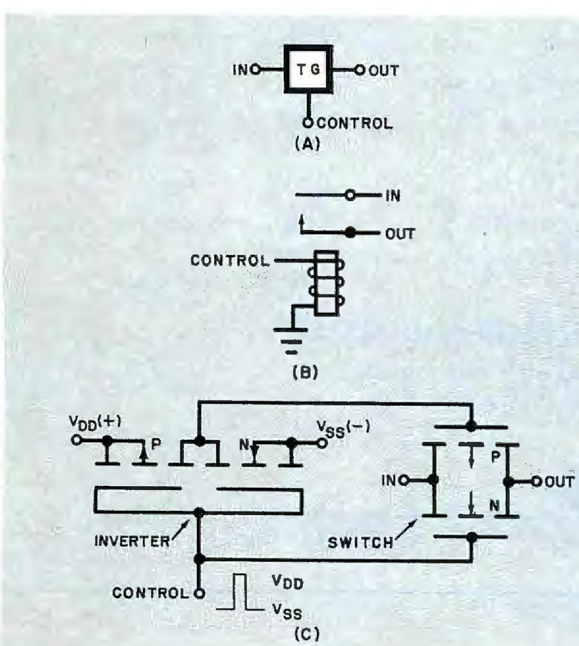


Fig. 1. Symbol (A), mechanical analog (B), and schematic (C) of a transmission gate. When control input is high, switch is turned on.

The practical answer to electronic switching requirements can be found in the type 4016 "bilateral switch" or transmission gate (TG). This is a unique form of logic found only in the CMOS family of devices. A high-speed, solid-state electronic spst switch, it can transfer ac or dc voltages or currents in either direction. It can switch at speeds up to 10 MHz, which is compatible with most modern digital systems. Although the TG's "on" resistance (300 ohms) is not the ideal short-circuit condition, its "off" resistance is extremely high. With a characteristic input resistance of 10^{12} ohms, it will not load down the switching source.

Theory. The symbol for a transmission gate is shown in Fig. 1A, while Fig. 1B illustrates the basic action of the device, similar to a relay contact which is closed when the CONTROL

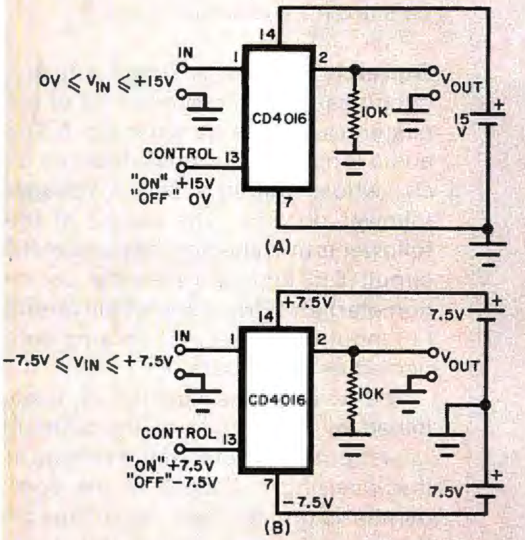


Fig. 2. The TG can switch positive dc signals (A) or bipolar signals (B), depending on power supply used.

input is high. The actual circuit for the TG, using enhancement FET's, is shown in Fig. 1C.

Note in Fig. 1C that, between the input and output terminals of the TG, there are an n-channel and a p-channel MOSFET. The gates of these MOSFET's are connected to the input and the output of an inverter. To turn on the TG, the CONTROL voltage should approximately equal V_{DD}. Conversely, to turn off the TG, the CONTROL voltage should be approximately V_{SS}.

The 4016 contains, in a 14-pin DIP assembly, four spst-type switches. Each switch has an "on" resistance of about 300 ohms over a 15-volt input-signal range, dependent on the values of V_{DD} and V_{SS}. The leakage current when the switch is off is about 10 pA, which is a result of its very high "off" resistance. The 4016 has an allowable control (clock) rate of 10 MHz, with a turn-on time of approximately 20 ns. As the recommended dc supply voltage is 3 to 15 volts, the input signal level must not exceed these values.

The 4016 can be used to switch positive dc or bipolar voltages as shown in Fig. 2. A peak potential of 15 volts (maximum) can be switched by the circuit shown in Fig. 2A. In this circuit, a single supply is required, with the V_{SS} terminal connected to ground. The Fig. 2B circuit illustrates how bipolar signals can be switched. Here, a split supply is used with the V_{DD} terminal at +7.5 volts and the V_{SS} terminal at −7.5 volts. In this case, the maximum input signal level can be 15 volts peak-to-peak. Note that in both circuits of Fig. 2, the control voltage is equal to V_{DD} for the "on" condition and to V_{SS} for the "off" condition. For most applications, the load resistance should be 10,000 ohms or greater. A maximum input signal frequency response of 40 MHz is attainable with V_{DD} at +5 volts and V_{SS} at −5 volts.

Switch Configurations. Because the 4016 contains four independent bilateral switches in one package, the individual switches can be arranged to function as a variety of switch types similar to the electromechanical switches for which they can be substituted. Two such arrangements are shown in Fig. 3. A pair of TG's can be wired to form a spdt switch as in Fig. 3A. Two such switches can be obtained from a single 4016. The control signals are out of phase as denoted by the line over one. This permits a conventional flip-flop to drive the switches.

The diagram in Fig. 3B illustrates how four TG's can be arranged to act as a dpdt switch. Again, the control inputs are driven out-of-phase in pairs, permitting the same flip-flop hookup.

Dual-Trace Converter. A dual-trace adapter for single-trace oscilloscopes is shown in Fig. 4. Besides the TG's, the circuit employs a 4001 quad-NOR IC as a multivibrator and phase inverter and a 536 operational amplifier IC.

This is a version of the principle of "time division multiplexing" in which each input of a two-channel system is coupled to the common output for a specific period of time, with the other channel shut off. The two channels alternate in supplying the output depending on the rate of the two-phase clock driving the multiplexer.

The op amp in this circuit is arranged as a summing amplifier. When one pair of TG's is on, it sums both the signal and the dc level determined by

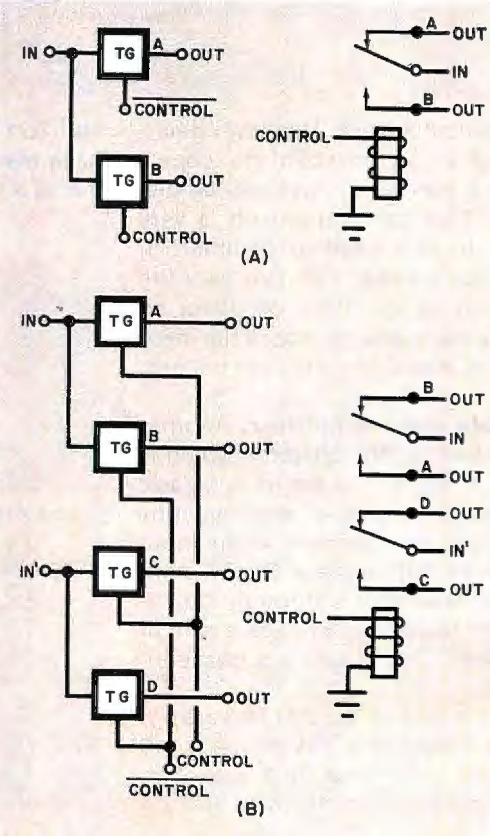


Fig. 3. Spst gates can be ganged for more complex switching circuits, such as spdt (A) or dpdt (B).

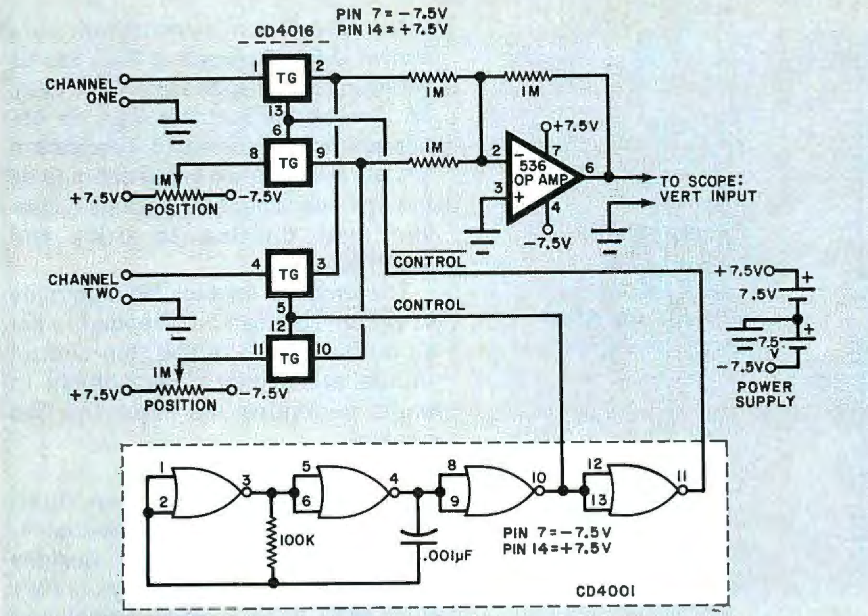


Fig. 4. TG's driven by a 2-phase clock time-multiplex vertical input.

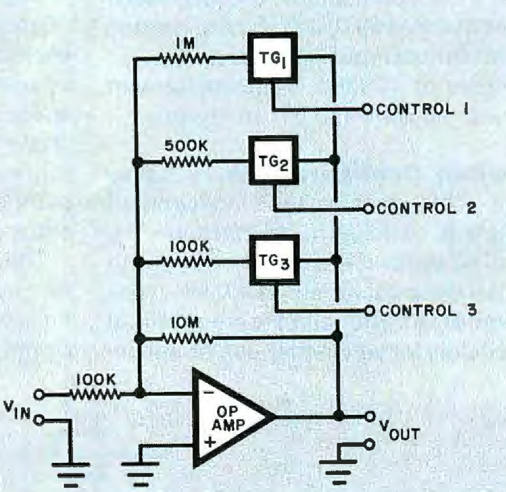


Fig. 5. In variable-gain amplifier, turning one of the TG's on sets the feedback resistance and, thus, gain of the op amp.

the POSITION control. This level determines where on the face of the scope's CRT that particular trace will be displayed. This basic approach is very similar to that used in commercial dual-trace scopes. You can vary the frequency of the clock oscillator so that it is not related to that of the input signal, thus avoiding a broken pattern.

Variable Gain Amplifier. Another application for the bilateral switch is shown in Fig. 5. The circuit is a basic op amp whose gain is determined by the ratio of the feedback to the input resistance. With none of the TG's on, the only feedback is through the 10-megohm resistor, to provide a gain of 100. (Note: This circuit is a phase inverter.)

If *TG1* is on and *TG2* and *TG3* are off, the total feedback resistance is 10 megohms paralleled by 1 megohm, producing a gain of 10. With *TG2* on and *TG1* and *TG3* off, the total feedback resistance of 500,000 ohms produces a gain of 5. Hence, the gain of the op amp is determined by which TG's are on and which are off.

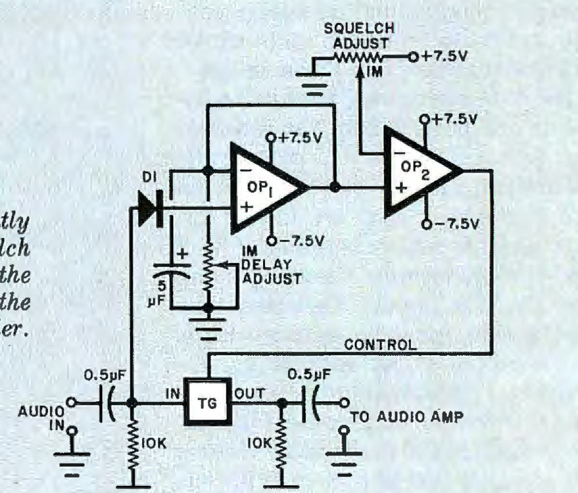
Squelch Circuit. A simple squelch circuit can be built with the aid of the bilateral switch as shown in Fig. 6. The audio input signal is peak detected by *D1*, whose output drives a voltage-follower op amp. The output of the follower is averaged by the parallel RC circuit (5 µF and the 1-megohm potentiometer) and drives the noninverting (+) input of the second op amp connected as a comparator.

The level of the squelch is determined by the setting of the SQUELCH ADJUST potentiometer. If the voltage at the inverting (−) input of the comparator is greater than the voltage on the noninverting input, the comparator's output is almost at the maximum negative supply voltage. This signal keeps the TG off so that the audio input signal will not pass through to the audio amplifier.

If the averaged signal produces a voltage at the noninverting input of the comparator greater than that supplied to the inverting input, the output of the comparator swings to the maximum positive power supply level. This action turns on the TG and allows the received audio to pass to the amplifier. The off delay (up to several seconds) is determined by the time constant of the RC circuit.

Closing Comment. In this article, we have covered only a very small fraction of the possible applications for the versatile transmission gate. With a knowledge of what the TG can do, you can create many new applications for this unique solid-state switch. ◈

Fig. 6. A sufficiently strong signal in squelch circuit will cause the comparator to turn on the TG, to drive amplifier.



MAC'S SERVICE SHOP

DUMMY ANTENNAS FOR HAMS AND CB'ERS

By John T. Frye, W9EGV

"HEY, boss, what are you doing with that crazy paint bucket?" asked Barney as Mac came through the door of the service department carrying a shiny black gallon bucket with printing, a diagram, and a chart emblazoned in white on the side.

"Watch your tongue," Mac said; "you're speaking of my new, almost-finished Heathkit 'Cantenna,' Model HN-31, RF Load Resistor."

"Pardon *me*!" Barney replied with exaggerated contriteness, "but I thought you used a foot-long, war-surplus, noninductive resistor for a dummy load."

"I do, but I'm already overloading it with just the hundred-watt key-down output from my ham SSB exciter. I don't dare put the output of the linear amplifier, which runs about seven times that, to the resistor. It would go up in smoke. This cantenna, however, is rated at a kilowatt ICAS and will take the 700 watts continuously for fifteen minutes—plenty long enough to melt down the final tubes in a SSB transmitter. Any owner of a SSB transmitter who sits on the key for even a tenth of that time is just plain stupid."

"You really think a dummy antenna is needed, huh?"

"Do I! I believe no ham or CB operator should be issued a license unless he possesses and *uses* a dummy antenna to load up his transmitter for testing. Putting an unmodulated carrier on the air for minutes at a time or performing unidentified testing is not only illegal but it stamps the perpetrator as a 'lid of the first water,' who has a total disregard for others."

Heathkit Cantenna presents a 50-ohm resistive load to the transmitter.

Why Use a Dummy Load? "There are other sound reasons for using a nonradiating load resistor. For one thing, almost all service literature requires that the transmitter be connected to a good dummy antenna at the proper impedance when testing. Results obtained with a mismatched or reactive load are at best meaningless and, at worst, quite likely to cause damage. Moreover, with a good dummy antenna you can establish a reference standard of performance. As soon as I finish the Cantenna, I plan to feed it with the exciter barefoot and then through the linear amplifier at a selected logged frequency on each band. In each case, I'll tune for maximum output and then log grid current, plate current, tank and load capacitor settings and relative voltage reading as indicated by the Cantenna's monitor circuit, which I'll discuss later. If I question performance at some future date, I can compare new readings with those I logged to see if anything has changed. If it has, I'll have some very helpful clues as to where the trouble lies."

"What makes a good dummy antenna?"

"First, it should present an accurate, unchanging, purely resistive load—usually 50 ohms—to the transmitter under a wide range of frequencies and power outputs. The load resistor should be shielded to prevent radiation, and capable of absorbing the maximum output of the transmitter at 100% duty cycle for a reasonable length of time. AM and full-power tune-up represent 100% duty cycle; CW, 50%; SSB, 33%. The dummy antenna should connect to the transmitter through coaxial cable and a coaxial antenna switch so the transmitter can be switched quickly from the antenna to the dummy load, and vice versa. Finally, it's helpful if the dummy antenna incorporates some method of indicating at least relative r-f input. Ideally, it will indicate actual wattage being absorbed and dissipated by the resistor."

"Those requirements eliminate a lot of things," Barney observed. "For instance, a 100-watt incandescent bulb can take a full 100 watts of r-f indefinitely and translate it into radiated light and heat, but its resistance changes from 10 ohms when cold to about 144 ohms at its normal operating temperature. You can imagine what happens to the resistance when you're pumping an SSB signal into the filament. Carbon resistors are very limited in the power they can absorb without damage. Wirewound resistors have inductance. But hey, how about giving me a peek at that grandaddy kilowatt resistor inside the bucket? I don't think I ever saw anything bigger than a couple of hundred watts wirebound."

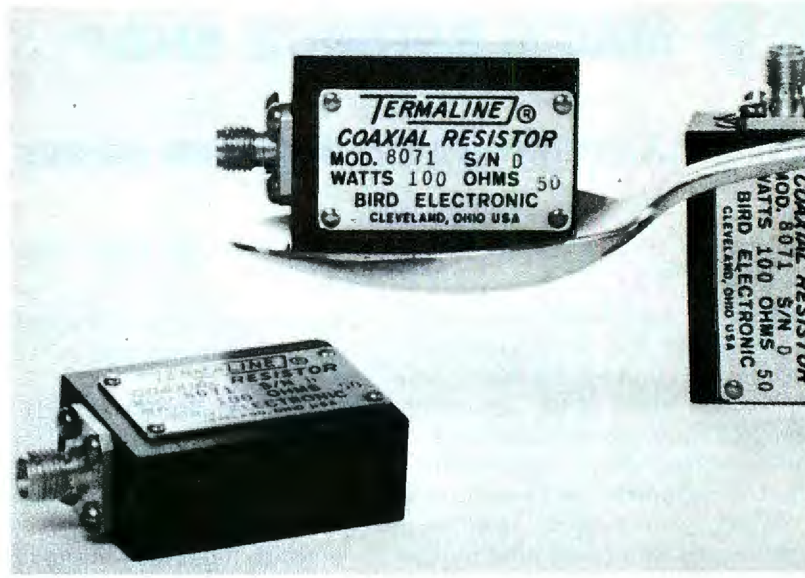
Smiling, Mac pried up the bucket lid with a screwdriver and set it upside down on the bench. Barney saw a 5" × 11½" aluminum tube fastened vertically to the bottom of the lid with two brackets that held the top of the tube about 1½" (3.8 cm) below the bottom of the lid. Inside the tube was a 5" (2.7 cm) film-type resistor on a hollow ceramic form ¾" (1.9 cm) in diameter. Silver-plated copper contact straps were bolted around the silvered ends of this resistor, which was centered in the bottom of the tube by four triple-nutted brass bolts. The bolts also made firm contact with the bottom strap. The top strap clamped the open ends of a U-shaped silver-plated bracket against the silvered contact surface. The center of this bracket was connected to a porcelain feed-through insulator that went through the lid into a metal box on the top.

"You mean to tell me that little resistor can dissipate a kilowatt?" Barney asked in disbelief.

"It can and will when I fill this bucket with non-conducting, high-temperature transformer oil. Much of the heat of the resistor will be transferred to the oil circulating around and through the resistor, effectively increasing the dissipation capacity at least a hundred fold."

"Why is the resistor inside the metal tube?"

"Two reasons: first, the diameter of the tube is proportioned to the diameter of the resistor so the combination submerged in oil has a surge impedance equal to that of a 50-ohm coax line. What we then have is a continuation of the coaxial cable with the resis-



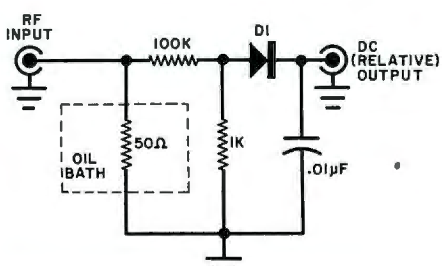
Bird's small dummy load can handle up to 100 watts from dc to 2 GHz, when heat-sinked to equipment panel.

tor serving as the center conductor of the last five inches of the cable. Incidentally, if this were a solid bar instead of a film type resistor, the r-f resistance would increase with frequency because the current would concentrate on the surface. That's why film resistors are used almost exclusively in dummy loads.

"The second reason for the resistor-in-a-tube combination is that it forms a 'thermal siphon' in the oil. Oil heated by the resistor expands, rises, and flows out the top of the tube. This pulls cool oil from the bottom of the bucket into the bottom of the tube. Heated oil rising to the surface spreads out radially and contacts the air-cooled walls of the bucket, where it gives up some of its heat and sinks to the bottom. All this creates a "closed-loop fountain" in the oil that aids in cooling the resistor."

"What's in that little box on the lid?"

"It carries the fitting for attaching the coax cable from the transmitter and also houses the components of the relative voltage monitoring circuit shown on this diagram on the side of



Power is dissipated by resistor in oil bath, while other components form a dc sampling circuit.

the bucket. A voltage divider across the r-f load resistor feeds a small fraction of the r-f voltage to a germanium diode for rectification. The 0.01-µF capacitor smooths the rectified signal which can then be measured with a VTVM or other high-impedence meter connected to the phono jack on the end of the box. Any change in r-f across the load resistor is reflected as a change in dc output. This permits a transmitter to be tuned for maximum output."

Output Wattage. "Can't you calculate transmitter output wattage from the meter reading?"

"No, because the resistive voltage divider is frequency sensitive. The reading goes up with frequency. This occurs because the carbon composition resistors in the divider tend to exhibit stray reactance. A capacitive divider, on the other hand, remains purely capacitive for a wide frequency range, and most Bird Termaline® wattmeters are designed with capacitive dividers."

"How did the birds get into this conversation?"

"The Bird Electronic Corporation of Cleveland is a leading manufacturer of coaxial load resistors, r-f absorption and directional wattmeters. Their dummy antennas, called Termaline Coaxial Load Resistors, come in sizes all the way from 2 watts to 50 kilowatts. These are precision, laboratory-grade instruments and are priced accordingly. While the low-cost Cantenna—which I consider adequate for most ham and CB use—is claimed to have a VSWR of less than 1.5 up to 300 MHz and less than 2.0 up to 400 MHz, a comparable air-cooled, liquid-dielectric Bird unit rated at 1 kW *continuous duty*, has a VSWR of 1.1 up to 1 GHz and only 1.25 up to 2.5 GHz."

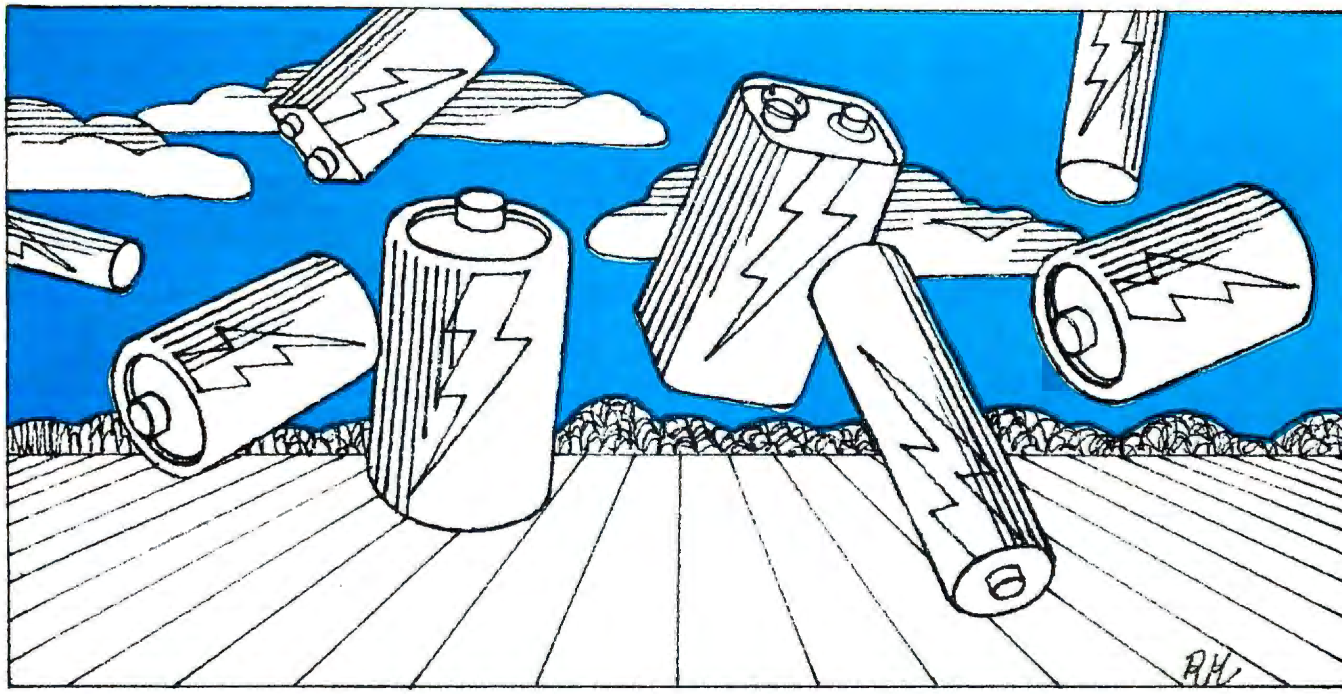
"How does Bird do it?"

"They start with a special high-precision film resistor that will maintain its 50-ohm value through all rated temperatures and frequencies. Instead of being a cylinder, the resistor shell tapers in a logarithmic fashion from the full diameter of the line at the top to only the diameter of the resistor at the bottom, where the two meet. A wave traveling down the line sees 50 ohms at the top of the resistor, 25 ohms at the center, and 0 ohms at the bottom. To insure a frequency-independent termination, the shell must be matched to the resistor at any point along its length. The shell is filled with a heat-conducting dielectric and is equipped with external heat-radiating fins. By combining a form of r-f voltmeter calibrated directly in watts with a coaxial load resistor, Bird forms their series of Termaline R-F Absorption Wattmeters.

"Bird makes load resistors that are dry-air cooled, air cooled with a liquid dielectric, cooled with forced air, and water cooled. Their absorption wattmeters operate from 2 to 500 MHz. They have Thruline® directional wattmeters that will read forward and reflected power at any point in a feed line.

"Now let me tell you how you can measure transmitter output with a Cantenna or similar dummy load. Connect the vertical deflection plates of a scope (already calibrated in peak-to-peak volts per inch deflection) across the line feeding the dummy load. Once you know the sine-wave p-p volts across the dummy load, convert this to rms volts by multiplying by 0.3535. Square this, and divide by 50 ohms to get the power in watts. For example, my exciter gives me 200 volts p-p, or 70.7 volts rms. The square of this is 4998—let's call it 5,000—and 5,000 divided by 50 is 100 watts. It's no coincidence this is the rated output of the exciter."

"I've just reached a conclusion," Barney announced with a sigh; "there's nohing dumb about dummy antennas!" ◈



BUILD THE BATTERY MULTI-CHARGER

Inexpensive circuit rejuvenates four types of carbon-zinc cells simultaneously.

BY RALPH TENNY

THE Multi-Charger described here can often rejuvenate carbon-zinc batteries used in radios and flashlights. It handles between one and six cells charging four *different* types simultaneously.

The rejuvenating process used is not recharging in the strict sense. Though there is a very limited amount of reversible electrochemical activity (such as occurs in nickle-cadmium and lead-acid storage batteries), the action is primarily one of driving hydrogen bubbles from the anode rod. In this way, internal cell resistance (the common cause of cell "failure") is reduced and operating lifetime is extended.

About the Circuit. The Multi-Charger consists of a bridge rectifier, two silicon diodes, six resistors, a potentiometer, and a monolithic transistor array. The heart of the circuit is a constant-current source, two versions of which are shown in Fig. 1. Assume that a constant dc voltage is applied to the V+ bus (Fig. 1A). Current flows through *D1*, *D2*, and *R2*, generating a reference voltage at point X. Since the magnitude of this voltage is less than that at V+, *Q1* is forward biased and collector current flows through the milliameter. The amount of current through the transistor can be set by potentiometer *R1* to bias *Q1* in an equilibrium condition. If the gain of *Q1* is very high, this current will be well-regulated. So, if a potentiometer is placed between *Q1* and the milliameter, a more or less constant current will flow, regardless of the potentiometer's setting.

A similar constant current source is shown in Fig. 1B. If a reference current (I_{ref}) is applied to the base and collector of *Q2*, it will flow through this transistor and *R3*, establishing a voltage drop across *R3* and the base-emitter

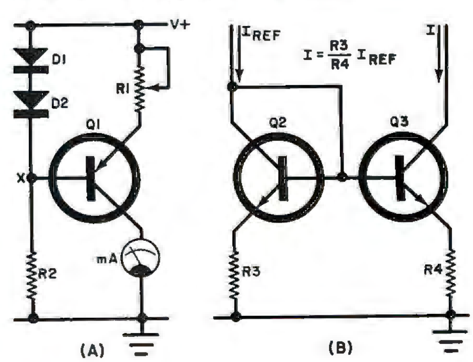
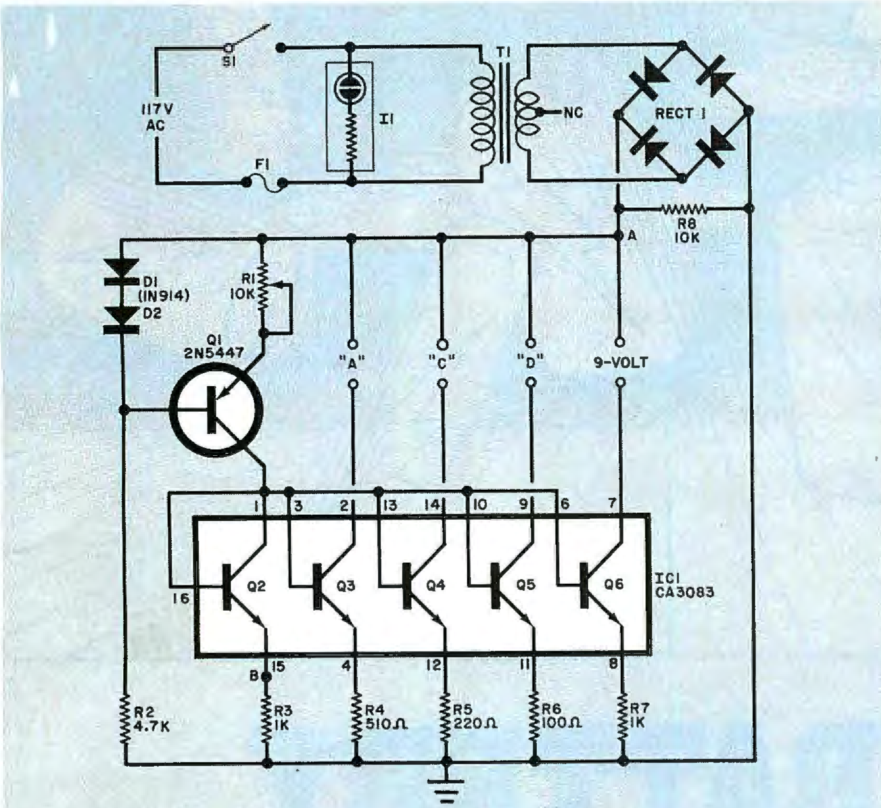


Fig. 1. In (A) reference voltage at X produces constant current in Q1. In (B) output I depends on reference current, R3, and R4.



PARTS LIST

D1, D2—Silicon signal diodes (1N914) or equivalent)
F1—¼-amp fuse
I1—Neon panel lamp assembly (Radio Shack 272-705 or equivalent)
IC1—CA 3083 monolithic transistor array (RCA)
Q1—2N5447, HEP S0019, or equivalent
R1—10,000-ohm linear taper potentiometer
R2—4700-ohm resistor
R3, R7—1000-ohm resistor
R4—510-ohm resistor
R5—220-ohm resistor
R6—100-ohm resistor
R8—10,000-ohm resistor
RECT1—1-amp, 50-PIV full-wave bridge rectifier (Radio Shack 276-1151, HEP R0801 or equivalent)
S1—Spst power switch
T1—12.6-volt center tapped, 100-mA transformer
Misc—Printed circuit or perforated board, hookup wire, solder, suitable enclosure, mounting hardware, fuseholder, machine hardware, etc.

Fig. 2. Circuits in Fig. 1 are combined in the charger.

junction of *Q2*. This voltage serves as a reference voltage like that at point A in Fig. 1A. Assuming that *Q2* and *Q3* are closely matched, as transistors formed on a monolithic block of silicon would be, and that *R4* is one-half the value of *R3*, then *Q3* will source a current (I) twice that of I_{ref}. If we employ a five-transistor array, four such current sources can be set up, with their outputs governed by the ratios of their emitter resistors. This is exactly what the Multi-Charger is. Its current sources can handle the four common ("A," "C," "D," and 9-volt transistor) cells.

In the actual circuit, whose schematic is shown in Fig. 2, the dc source is not a constant value, but rather the unfiltered output (at point A) of a full-wave bridge. Its waveform is shown in Fig. 3A. Accordingly, *D1* and *D2* don't conduct all the time, so *Q1's* collector current will have a "clipped" waveform. Reference current for *Q2*, and the charging current outputs of *Q3, Q4, Q5,* and *Q6* will pulsate in the same manner. Emitter current (at Point B in Fig. 2) of *Q2* is shown in Fig. 3B. Since the output and reference currents in a circuit like that in Fig. 1A (or the transistor array *Q2, Q3,* etc. in Fig. 2) are alike when *R3* and *R4* are equal, the circuit is called a "current mirror" or "current reflector."

The Multi-Charger will work simultaneously with any number of each type of cell, up to 9 volts total. Readily available battery holders for two, four, or six cells can be used across each set of charging terminals.

Construction & Use. Fairly simple circuitry allows flexibility in assembling the Multi-Charger. Printed circuit board, perfboard, or wire-wrap techniques can be used. If battery packs are used, bring out the charging terminals through the case (using grommets) for quick connection.

When construction is complete, set potentiometer *R1* for maximum resistance and attach a milliammeter across the 9-volt transistor battery terminals and set *R1* so that 1 mA flows through the meter. Then check the other output terminals—charging currents should be 2 mA ("A" cells), 5 mA ("C" cells), 10 mA ("D" cells). Observe the 9-volt limit when using battery packs. Although an 8-cell pack (12 volts) will not damage the Multi-Charger, the charge rate would be prohibitively slow.

Since the required charging time will vary with cell usage, keep a record of the charging time compared to operating time. Make it a practice to check cell voltage, and recharge before it drops too low. A good recharge point is 1.4 volts per cell for "A," "C," and "D" cells, and about 8.8 volts for 9-volt transistor batteries. Mark each battery (scratch the case paint) each time you charge it to keep track of the number of charging cycles. Examine each cell carefully before a new cycle, to make sure that the case is not deteriorating. After a while, your records will enable you to predict the end of useful life for cells from each manufacturer.

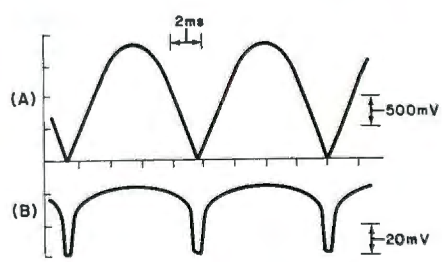
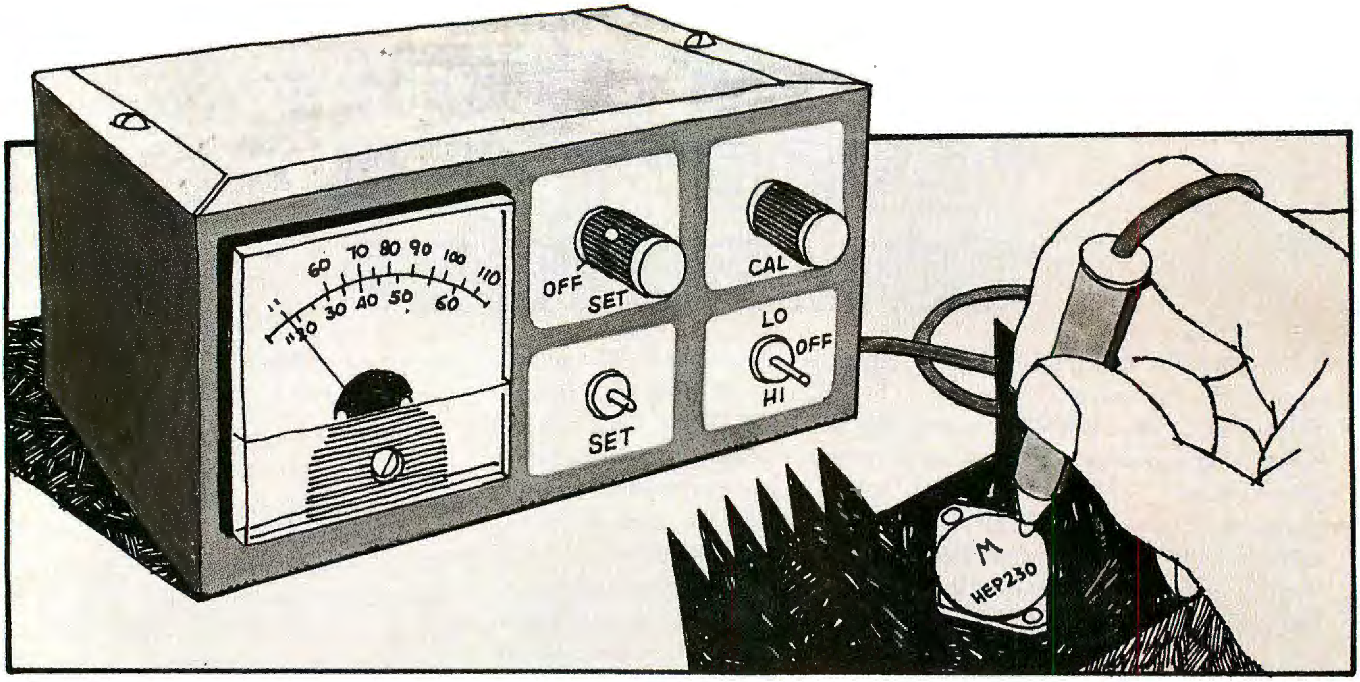


Fig. 3. Waveform (A) is output of a full-wave bridge rectifier. Outputs of Q2 through Q6 pulsate as shown by waveform at (B).

Finally, keep these ideas in mind when using the Multi-Charger:

- Use only good-quality batteries with heavy metal cases. It's false economy to buy cheap cells that will probably damage the appliance through electrolyte leakage.
- *Never* leave run-down batteries in *any* appliance.
- Avoid leaving cells with several completed charging cycles in any device, since the charging process accelerates any tendency of the cells to leak.



BUILD A LOW-COST
TEMPERATURE METER

Identifies hot spots in your electronic equipment.

BY WILLIAM A. RUSSO

SOLID-STATE devices are notoriously heat sensitive. They tend to self-destruct if certain operating temperatures are exceeded for even a short time. Hence, keeping tabs on component temperatures can often be critical. The only way to distinguish accurately between a power transistor operating at a relatively cool 90° C and one ready to destruct at 120° C is with a fast-acting thermometer. The electronic thermometer described here, which you can build for about $15 worth of parts, fills the bill nicely.

The thermometer is useful for a number of different temperature-measuring applications. Aside from keeping tabs on component temperatures, it will measure the thermal resistance of a heat sink and tell you how well thermal grease improves the heat transfer from a component to the sink. Furthermore, it can tell you if the movement of the air inside the chassis of an expensive project you just built is sufficient to maintain the temperature below the recommended 70° C commercial limit.

As designed, the electronic thermometer can measure the temperatures of noncorrosive liquids and gases as well as the surface temperatures of solids. It has an approximate measurement range of 20° C to 110° C (in two switch-selectable ranges) and an accuracy of roughly ±5° C. The temperature probe has a low thermal mass to assure virtually instantaneous metering indication. Finally, the project is battery powered for both bench and field use and to eliminate the danger of electric shocks.

About the Circuit. The schematic diagram of the thermometer is shown in Fig. 1. It consists essentially of a resistor (thermistor) connected in series with a meter movement (*M1*) across battery *B1*. As the resistance of the thermistor, *RT*, varies with changes in temperature, the current through the meter varies in step with it, changing pointer deflection. With the thermistor specified, as temperature increases, *RT*'s resistance decreases and more current goes

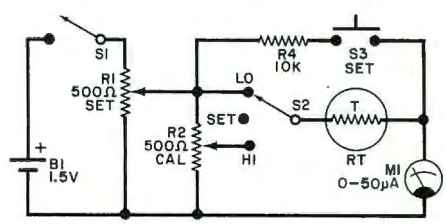


Fig. 1. Probe RT senses temperature.

PARTS LIST

B1—1.5-volt D cell
M1—0-to-50-μA dc meter movement (Radio Shack No. 22-051 or similar)
R1—500-ohm linear-taper potentiometer
R2—500-ohm trimmer potentiometer
RT—Thermistor (50,000 ohms at room temperature)
S1—Spst switch (part of R1)
S2—Spdt switch (center off)
S3—Normally open spst pushbutton switch
Misc.—Suitable box (6¼" × 3¾" × 2") with cover; battery holder; cable for probe; terminal strips; control knob; mounting hardware; heat-shrinkable tubing; hookup wire; solder; etc.
Note: The thermistor is available from Delta Electronics, P.O. Box 1, Lynn, MA 01903 as part No. B5160 for 50¢ each. Minimum order is $5.00. Also, a complete insulated probe assembly with 5' of cable is available for $3.75 (postpaid USA) from William A. Russo, 5 Main St., Acton, MA 01720.

TRANSISTORS AND HEAT

High junction temperature is the main culprit in the premature failure of semiconductor diodes and transistors. Since the semiconductor case is sealed, the actual junction temperature cannot be measured directly, but you can measure the case temperature T_C. This can then be related to junction temperature T_J using the formula

$$T_J - T_C = P_T\theta_{JC}$$

where P_T is the power dissipated in watts and θ_{JC} is the junction-to-case thermal resistance in degrees C/watt. The former is roughly equal to $I_C \times V_{CE}$ (dc or the rms ac values) for a transistor. You can find θ_{JC} listed on manufacturers' data sheets either explicitly or in the form of a dissipation derating curve such as that shown in Fig. 3 (which is for a 2N3789). In the curve, θ_{JC} is equal to the magnitude of the curve's slope from the knee (at 25 degrees C here) to the point at which $P_T = 0$ (200 degrees here.) Thus θ_{JC} = 175 degrees ÷ 150 watts = 1.17 degrees/watt. Another way to present this data is in words. The 2N3789 data sheet, for example, says: "Continuous device dissipation at or below 25 degrees C case temperature = 150 W; derate linearly to 200 degrees C case temperature at the rate of 0.855 W/deg." The figure "0.855 W/deg" is the reciprocal of θ_{JC}.

Do not confuse θ_{JC} with θ_{JA}. The latter is the junction-to-ambient thermal resistance and is always much lower than θ_{JC}. It is useful for calculating T_J when no heat sink is used:

$$T_J - T_A = P_T\theta_{JA}$$

When a heat sink is used, the above formula applies with θ_{JA} replaced by $\theta_{JC} + \theta_{C-HS} + \theta_{HS-A}$ where the last two terms characterize heat sink performance and are specified by heat sink makers. These heat sink parameters, however, are very dependent on heat sink orientation and air flow, and the most useful data in any particular usage can best be obtained from direct temperature measurement.

Suppose you are using a 2N3789 in a voltage regulator circuit with V_{CE} = 8 volts rms, with I_C = 5 amps. The metal front panel of your case is doubling as a heat sink. Is it adequate? To find out, first establish thermal equilibrium at full load current and measure T_C. If equilibrium can't be reached (the temperature just keeps rising) the heat sink is too small. Assume we measure T_C = 100 degrees and T_A = 25 degrees at equilibrium. Calculate P_T = 8V × 5A = 40 watts. Referring to the curve, P_T (max) at 100 degrees case temperature is around 85 watts, more than double the power we're using, so we know the heat sink is OK. It is easy to find θ_{CA} too:

$$\theta_{CA} = (T_C - T_A)/P_T = (100 - 25)/40 = 1.875°C/W$$

which can be filed for future reference and used for finding T_C in projects using the same heat sink.

In this example, we assumed a T_A of 25 degrees C on both sides of the heat sink, but this is not always the case. The temperature on one side may be much higher due to component heating inside the cabinet. This will be reflected in a higher T_C.

For maximum reliability, transistor and rectifier case temperatures should not exceed 100 degrees C for silicon devices and 75 degrees C for germanium units.

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through *M1* to produce an up-scale pointer deflection.

Potentiometer *R1* is used during initial setup to compensate for variations in battery voltage due to aging and power consumption. Potentiometer *R2* is used to set the proper scale factor for the HI temperature range. Switch *S3* and resistor *R4* substitute for *RT* (*S2* in SET position) when adjusting *R1*. Long life can be expected from *B1* because the drain is on the order of only 6 mA or less.

Construction. With the exception of the thermistor, the entire circuit can be quickly point-to-point wired inside a small box. Access to trimmer potentiometer *R2* is required only during initial setup. Switched potentiometer *R1/S1*, switches *S2* and *S3*, and meter *M1* mount on one wall of the box.

Exercise care when preparing the probe assembly because excessive soldering heat or mechanical stresses on the thermistor can permanently damage it. At the thermistor end of a 6' (about 2 meters) length of thin, flexible two-conductor cable (such as the type used for intercoms), slit and remove about a 2" (5-cm) length of the cable's plastic jacket. Save the removed piece. Next, cut off 1" (2.5 cm) of one of the cable's wires and strip 1" of insulation from the longer wire and ½" (1.27 cm) from the shorter wire.

If you examine the body of the thermistor, you will note that the end containing the thermistor is sealed with a metal cap and the other end looks like the point of a ballpoint pen. It is to this latter end that the cable leads will be soldered. Use a sharp knife to carefully scrape the solder coating around the tip. Then use the knife to clean a shiny band about ¼" (6.4 cm) wide and about ¼" down from the tip on the main shank (near the indented bands).

Wrap the stripped end of the cable's longer wire around the cleaned band on the shank and the shorter wire around the tip of the thermistor. *Do not twist the probe tip!* Bend the cable to the desired cable/probe angle. Now, using a cleaned, hot, tinned, low-wattage soldering iron and fine solder, quickly but carefully solder the cables to the probe.

To give it more mechanical strength, wrap around the probe's soldered joints the piece of reserved plastic jacket. Slip a 2" long length of heat-shrinkable insulation over the assembly and shrink it into place.

At the free end of the cable, prepare the ends of both conductors and solder them to the appropriate points in the circuit. The cable can enter the box through a small hole lined with a rubber grommet.

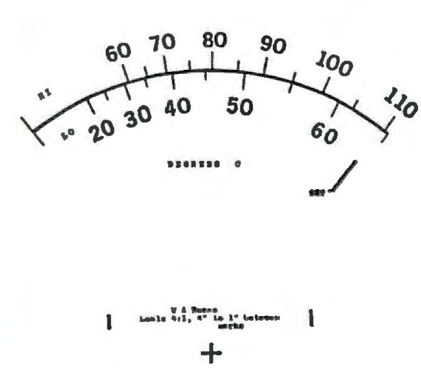


Fig. 2. Use this scale with the meter specified in Parts List to obtain an accuracy within 5°C.

Setup and Use. With an ohmmeter, you should measure about 50,000 ohms across the circuit ends of the probe cable. (The measurement will

be slightly lower if the probe has just been handled.) An ohmmeter reading that differs sharply from this may mean that the thermistor has been permanently damaged during assembly. If the reading is infinity, don't jump to the immediate conclusion that the thermistor is at fault, however. First check the cable and soldered connections at both ends to determine if the circuit is complete. On the other hand, if the thermistor yields a low-resistance reading at all times, it must be replaced.

Install *B1* in its holder. Place *S2* in the LO position and rotate *R1* until *S1* closes. Adjust *R1* until the meter's pointer deflects about half way up-scale. If the meter operates erratically, dirty or poorly adjusted battery holder contacts are usually the blame. Rectify the problem before proceeding by cleaning and/or bending inward the battery contacts.

Temporarily connect a 2000-ohm, 5% tolerance resistor (or any resistor whose value is between 1900 and 2000 ohms) across the thermistor cable. Set *S2* to HI and adjust *R2* for full-scale pointer deflection. Set *S2* to SET, depress and hold down *S3*, and adjust *R1* for a full-scale meter pointer deflection. Release *S3*. (Repeat the adjustment of *R1* and *R2* until there is negligible error in either the HI or SET positions of *S2*.) Remove the 2000-ohm resistor from across the cable. Trimmer pot *R2* is now properly adjusted and should not have to be disturbed again.

From this point on, before each use, switch *S2* to SET, depress *S3*, and adjust *R1* for a full-scale meter deflection.

For initial calibration, set *S2* to LO. Insert a mercury thermometer whose accuracy is known and about ½" of the probe tip into a container of cold water. Once the mercury thermometer has stabilized, you can make a table of °C versus meter scale indications. Calibrate the LO scale from 20° C to 60° C and the HI scale from 60° C to 110° C in 5° intervals, setting *S2* to the proper range as necessary. If you prefer, you can use the scale shown in Fig. 2 with the meter specified in the Parts List to obtain an accuracy within 5° C of the reading indicated by the meter's pointer.

To use, first adjust *R1* as described above. Then, after selecting the high or low meter range, touch the probe tip to the component whose temperature is to be measured. Allow a few seconds for the probe tip to come up to temperature. Then read the temperature directly off the meter. For added accuracy, coat the tip of the probe with heat-sink grease to promote heat conduction. *Do not attempt to measure temperatures greater than 150° C* or you will destroy the thermistor. Note also that you must wait a few seconds when measuring air temperatures for equilibrium to be reached.

For liquid temperature measurements, immerse about ½" of the probe's tip in the liquid. The meter's response will be almost instantaneous because of the high-efficiency heat-transfer characteristics of a liquid medium.

When probing around in an electronic circuit, keep in mind that the probe's tip is metal and must be handled in the same manner as you would handle any other probe. With a little experience, you will develop a "feel" for the correct operating temperatures of various components, which you can mark on schematic diagrams for future reference. (See Fig. 3 for typical transistor case temperature versus device's continuous power

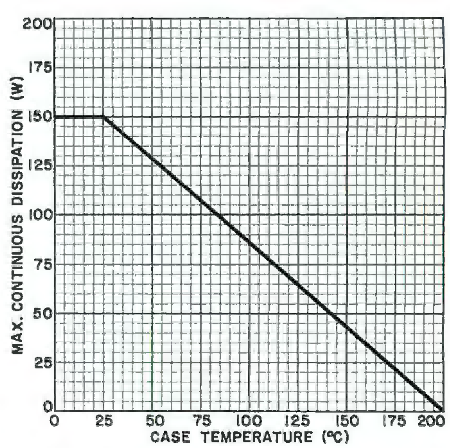


Fig. 3. Temperature vs. power dissipation for 2N3789 transistor.

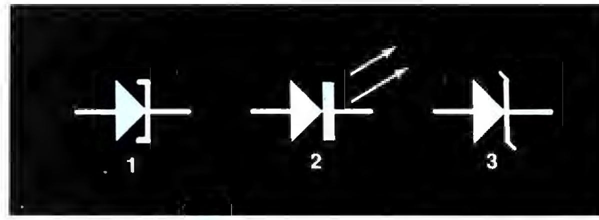
dissipation.) As a starter, many silicon devices (not thyristors) frequently are operated at temperatures in excess of 100° C, as are many power resistors. For best results, germanium and silicon thyristors should be operated at temperatures below 100° C. In well-designed circuits, passive components and IC's should be operated so that they generate maximum temperatures of about 70° C.

When transporting the electronic thermometer, it is a good idea to set *S2* to HI to damp the meter movement and prevent pointer damage. ◈

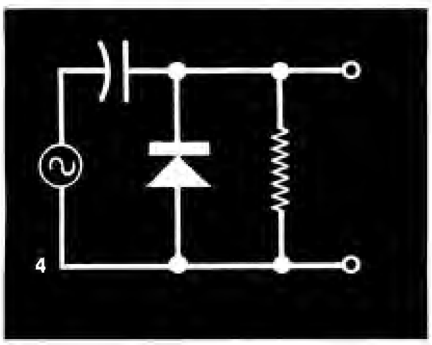
WHAT DO YOU KNOW ABOUT DIODES?

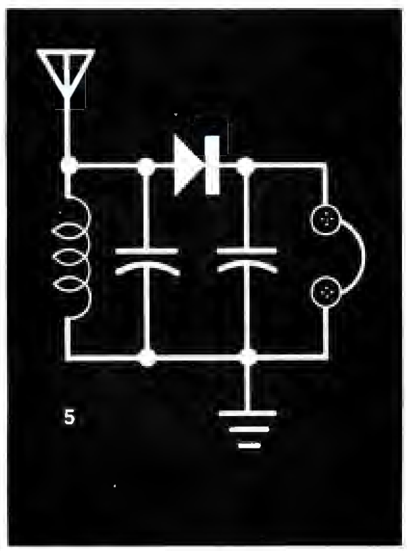
BY ROBERT P. BALIN

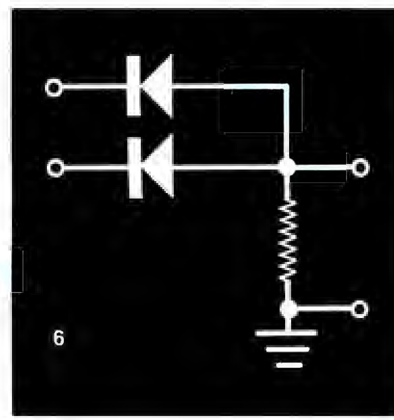
Diodes are deceptively simple electronic components. Even though they consist of just two elements (anode and cathode), their proper application requires a good understanding of how they work. See how many of the following questions you can answer. Numbers of questions refer to numbers on diagrams. Answers are below.



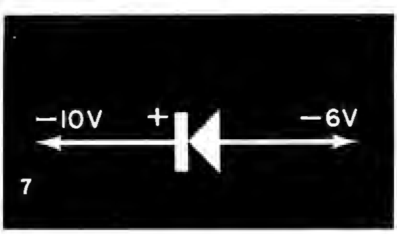
1. 2. 3. What types of diodes do these symbols represent?



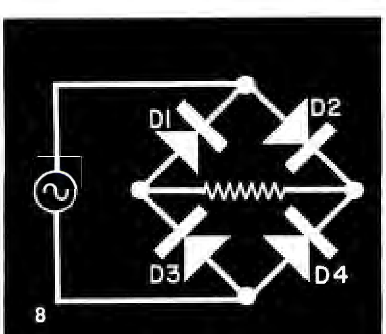




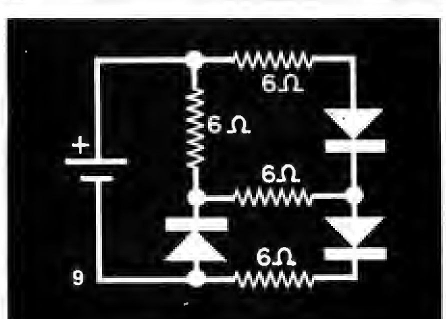
4. 5. 6. What are the functions of the diodes in these circuits?



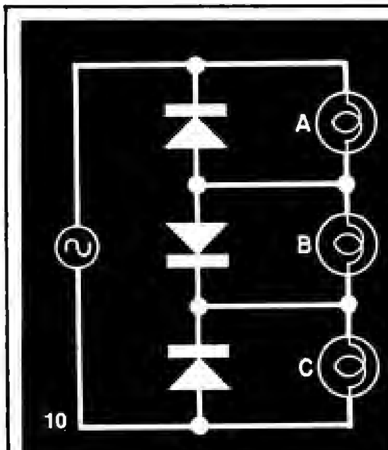
7. Is this diode forward or reverse biased?



8. Which of the diodes in this full-wave bridge has been wired incorrectly.



9. What is the total resistance across the battery if the diodes have zero forward resistance and infinite reverse resistance.



10. Which lamp will be the brightest?

Answers: 1. Tunnel. 2. Light-emitting. 3. Zener. 4. Clamp. 5. Detector. 6. Digital gate. 7. Forward. 8. D3. 9. 10 ohms. 10. B (On the positive half cycles, lamp B is shorted out and A and C in series each receive half of the line voltage. On the negative half cycle, lamps A and C are shorted out and B receives full line voltage.)

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Product Test Reports

ABOUT THIS MONTH'S HI-FI PRODUCTS

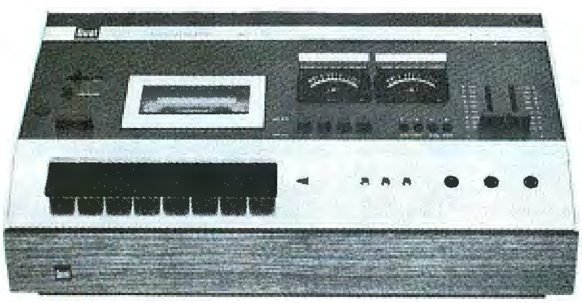
Dual's new cassette deck combines the convenience of auto-reverse playback and bi-directional recording with excellent flutter and signal-to-noise characteristics. The designers (probably utilizing their experience with record players) have introduced a viscous-damped cassette cover to eliminate the "pop-up toaster" effect found in many cassette ejection systems. Best of all, the quality of the performance matches the novelty of the design at a price competitive with other deluxe cassette decks.

There would seem to be little that could be done in the way of innovations in the design of small bookshelf speaker systems. However, Jensen Sound Laboratories has managed to make a small system that looks unlike its many competitors (without using bizarre styling) and sounds unlike them as well. The Jensen OPC 21 is as easy to look at as it is to hear—with a $70 price tag.

—Julian D. Hirsch

DUAL DELUXE CASSETTE DECK

Features bi-directional recording and automatic playback reversing.



HIRSCH-HOUCK LABS REPORT

The Dual name, long associated with record players, now appears on a deluxe stereo cassette recorder. The bi-directional deck is designed to record and play back in both directions without requiring the user to turn over the cassette at the half-way point. Reverse operation is automatic during playback and the deck can be set to repeat indefinitely.

The single-motor transport uses the same motor that powers the company's Model 1229Q record player. A heavy flywheel filters out the pulsations of motor torque that could cause flutter, and two separately driven belts turn the capstan and tape hubs. The piano-key operating controls can be pressed in any sequence without risking tape damage.

The deck features a walnut finished base. Its overall dimensions are 16½"W × 11$\frac{13}{16}$"D × 4½"H (42 × 30 × 11.4 cm), and its weight is 15¼ pounds (7 kg). Retail price is $450.

General Description. The recorder is basically a horizontal, top-loading deck. However, it can also be operated vertically when used with mounting legs furnished with it. Pressing the EJECT key causes the cassette cover to swing open slowly. The cover retains the cassette under light pressure to prevent it from falling out when the deck is operated vertically.

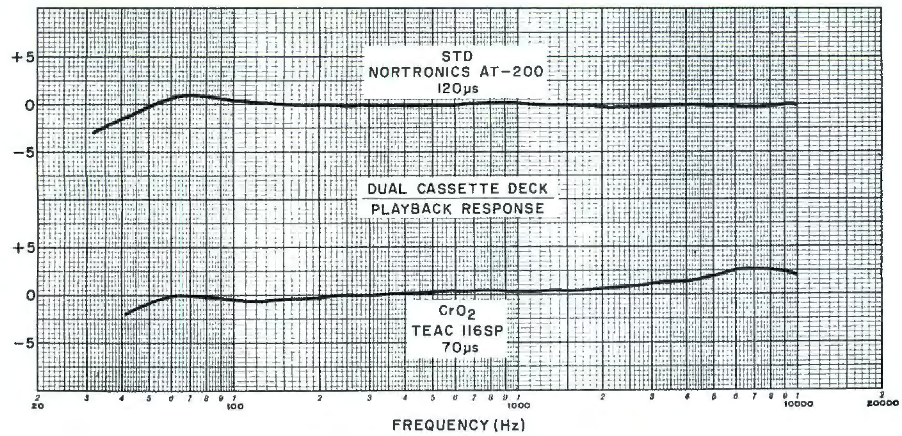
A switch is provided for optimizing both bias and equalization for STD (ferric-oxide) and CrO_2 (chromium-dioxide) tape formulations. Normally, this switch is left in the STD position, although it can be manually moved to CrO_2 at any time. If a CrO_2 cassette has the appropriate edge notch in its case, the tape switch will automatically go to the CrO_2 position when the cassette is inserted into the deck.

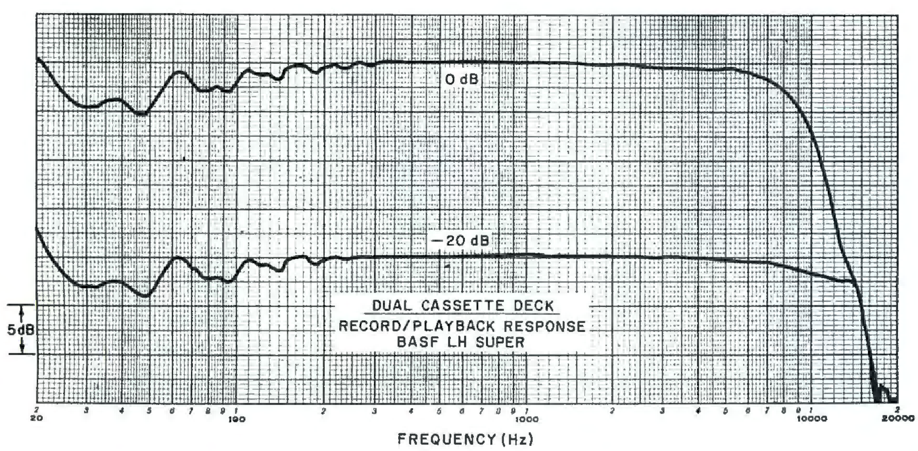
The piano-key operating controls appear to be conventional, but there are a few more of them than usual. The key functions are: STOP, CONT PLAY (the only one that mechanically latches and must be pressed a second time to unlatch), RECORD (identified by a red bar), normal and fast speeds in both directions, and PAUSE. Arrows illuminated in red indicate the direction of tape travel. Small signal lights indicate momentary recording levels that exceed +3 dB, RECORD status, and DOLBY operation. A headphone jack for low-impedance (8-to-16-ohm) phones and two ¼" microphone jacks for low- to medium-impedance dynamic microphones are also provided. There is no separate power switch. To apply power, the user simply presses one of the operating keys. Power shuts off completely when the tape ends or the STOP key is pressed.

Two illuminated level meters that can lie flat or be angled upward about 30° for better visibility from the front of the deck are calibrated from −20 to 0 dB in black for normal operating levels and in red from 0 to +5 dB for higher levels. The Dolby trademark symbol is positioned on the meter scales at the +3-dB point, which corresponds to the normal Dolby calibration of 200 nanowebers/meter. (The deck's internal calibration system produces a 0-dB playback indication from its test tone.) The movements are designed to have the ballistic response of a true VU meter.

Four small black pushbuttons in front of the meters are for MONO recording (paralleling the two channels), automatic level control (ALC), switching in and out the Dolby circuits, and injecting a test tone for calibration of the Dolby system. Four screwdriver controls on top of the deck are provided for making calibration adjustments, separately for each channel and STD and CrO_2 tapes.

Slide-type controls are used for setting recording levels. Playback from the deck is at a fixed level. Phono jacks for the LINE inputs and outputs are located on the rear of the deck, as is a DIN socket. When a microphone is plugged into one of the MIC jacks, the





corresponding LINE input is disabled and replaced by the microphone.

Laboratory Measurements. We measured the playback frequency response of the deck with Nortronics AT200 tape for the STD (120-μs) and Teac 116SP tape for the CrO_2 (70-μs) equalization. The STD response was within +1.5/−3 dB from 31.5 to 10,000 Hz. It was a very flat ±0.5 dB from 100 to 10,000 Hz. The CrO_2 response was within +3/−2 dB from 40 to 10,000 Hz.

The overall record/playback response was measured with BASF LH Super tape (for which the deck was biased) and TDK KR tape for the CrO_2 bias. At a −20-dB level, both tapes gave essentially the same response, within ±2.5 dB from 20 to 14,000 Hz. The useful response extended to the lowest audio frequencies. In fact, it reached a maximum at 20 Hz. The response was the same in both directions of tape movement.

We tried several other high-quality ferric-oxide (and ferrichrome) tapes on the deck and found little difference between them. For example, TDK ED and SA tapes gave almost exactly the same results as the BASF LH and TDK KR tapes. (The output from the SA tape was about 3 dB greater.) Maxell UDXL tape gave an extraordinarily flat high-frequency response, almost ruler-flat to beyond 15,000 Hz before dropping off, while Scotch Classic, a ferrichrome tape, gave a slight peak at 15,000 Hz. All the tapes were within the deck's ±2.5-dB tolerance over the specified frequency range.

A standard Dolby-level tape produced a +4-dB meter reading (1 dB above the Dolby mark on the meter scale) on playback. The tracking of the Dolby circuits, between the recording and playback characteristics, was excellent at −20 and −30 dB, with less than 1 dB of change in frequency response when the Dolby circuits were switched in and out.

A 70-mV LINE or 0.2-mV MIC input was required to record at a 0-dB level. The resulting playback output was 0.78 volt with CrO_2 tape and 0.85 volt with STD tape, corresponding to meter readings of +0.5 and +1.5 dB.

The playback THD at a 0-dB level was 1.3%. To reach the standard 3% THD reference level, the input level had to be increased to +7.5 dB with STD and +5.5 dB with CrO_2 tape. The unweighted S/N, referred to the 3% level, was 54.5 dB with both tapes. It increased to 60 dB with IEC "A" weighting. With the Dolby system switched in, the weighted S/N was an outstanding 67.5 dB with standard and 66 dB with chromium-dioxide tapes. The noise level increased by 11 dB through the MIC inputs at maximum gain, but the increase at normal settings was slight.

The PEAK indicator began to come on at +2 dB. As claimed, the meter ballistics matched professional VU-meter standards. The meters indicated 100% of their steady-state values on 0.3-second tone bursts.

When the ALC switch is pressed, the normal gain controls are disabled. The gain is rapidly reduced when a signal appears at the deck's input. It increases very gradually when the level drops off. It is impossible to force the meter to deflect beyond the +3-dB mark, even momentarily, when using ALC. Most of the time, the pointers stay well below the 0-dB point. Because of this, it is impossible to make a distorted recording with ALC, but the audible compression and slow "breathing" as the gain changes make this feature usable only for voice recording.

The operating speed of the transport was within 0.1% of the nominal 1⅞ ips (4.7 cm/s). The unweighted rms flutter was unusually low at 0.1% residual of our test instruments and tapes. The results were identical in both directions of tape movement. The fast speeds were really *fast,* passing a C-60 cassette from end to end in only 49 seconds.

User Comment. In its basic recording and playback functions, this deck is on a par with the best of today's fine cassette decks. Its bi-directional recording and playback capability gives it a large measure of added utility.

The deck has some distinctive operating characteristics that must be learned by the user. For example, to prevent accidental erasure of previously recorded material, tape reversal must be initiated manually in the record mode. The safety tab on a cassette, which must usually be removed to protect each side of the cassette against unwanted recording, blocks the recording function in both directions. The same applies if only one tab is removed. Hence, both tabs must be on the cassette to restore the recording function.

Automatic reversal of the tape's motion is a great convenience during playback, especially with a cassette that has a program that continues

onto the next side. However, it cannot be disabled. As a result, some people might find an unwanted side being played before they can react and shut off the deck. The reversal action is so smooth and rapid that it can easily be missed if one is not listening carefully. The automatic tape bias feature, likewise very convenient, depends on whether or not the cassette has the specially notched back edge (for CrO_2 tapes). Most cassettes have this notch, but many older ones do not.

The transport controls operated very smoothly and positively. The keys do not remain locked down, with the result that one learns to depend on the highly visible indicator lights on the deck to keep tabs on the operating mode and direction of tape movement. Because of the proximity of the control keys to each other and lack of visual distinction between them, we deem it advisable to look at the keys when operating them. On the other hand, one can go directly from one speed and direction to any other speed and direction without first having to operate the STOP key. Fast cueing is accomplished by holding down the STOP and fast-movement keys simultaneously. The tape then stops instantly when the fast key is released.

The deck's low noise and flutter are excellent, which, with its exceptional operating versatility, makes the Dual cassette deck worthy of consideration for discriminating audiophiles.

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JENSEN MODEL OPC 21 SPEAKER SYSTEM

Smooth-sounding $70 bookshelf speaker system.

With a fresh new styling approach, Jensen Sound Laboratories has designed a line of loudspeaker systems with what it calls an "Optimum Performance Concept," or OPC for short. Jensen claims that the OPC speaker systems have a higher power-handling capability than previous systems of comparable size. The lowest-cost speaker system in the OPC line is the two-way Model OPC 21, with a suggested retail price of $69.95. It measures 18⅜"H × 11"W × 8¾"D (46.7 × 28 × 21.3 cm) and weighs only 14 pounds (6.4 kg), which qualifies it as a true "bookshelf" speaker system.

The cabinet is covered with wood-grained vinyl with a perforated plastic grille in contrasting light and dark brown shades. Diagonally across the grille is a translucent brown plastic strip, behind which is a knob for tweeter level control. Access to it is provided by lifting off the plastic strip.

The entire grille can be removed to reveal an 8" (20.3-cm) woofer with flexibile plastic surround and a 2 ¾" (7-cm) cone-type tweeter. A foam plastic ring surrounding the tweeter apparently serves to smooth the response. Recessed into the rear of the cabinet are the insulated spring-loaded connectors for hookup to the cable coming from the driving amplifier.

Laboratory Measurements. The frequency response of the speaker system above 1500 Hz was exceptionally smooth, varying by only ±1.5 dB up to 16,000 Hz. There was a "jog" in the response curve at about 1000 Hz, with a variation of about ±3 dB within the 750-to-1500-Hz octave. At lower frequencies, the output dropped slightly to a minimum at 250 Hz and rose to a maximum at 85 Hz and then dropped off at a 12-dB/octave rate as the frequency lowered.

The high-frequency level control was able to cut off the tweeter completely. Its effect began at about 2000 Hz, which we judge to be the crossover frequency between tweeter and woofer. The bass distortion characteristics of the speaker system were very good for this size/price range. From 100 down to 55 Hz, at a 1-watt drive level, the THD was less than 1%. It rose at lower frequencies to 5% at 40 Hz and 7.5% at 35 Hz. At 10 watts input, the distortion was about 2.5% in the 80-to-100-Hz range, increasing to 8% at 50 Hz and to 14.5% at 35 Hz. We also measured the distortion with the drive level adjusted to maintain a constant 90-dB sound-pressure level (SPL) at a distance of 1 meter from the speaker system. It was similar to the 1-watt drive curve down to 70 Hz, where it rose more rapidly at lower frequencies—to 2.1% at 60 Hz and 6.6% at 50 Hz.

The system's impedance was just slightly less than 5 ohms at 20 Hz and in the 100-to-200-Hz range; and it measured between 5 and 16 ohms from 200 to 20,000 Hz. At the 73-Hz bass-resonance peak, the impedance reached a maximum of about 28 ohms.

As with many acoustic-suspension speaker systems, the Model OPC 21's efficiency was quite low. With a 1-watt power input in the midrange, the SPL at 1 meter away measured 89 dB. The tone-burst response was generally good, with only a moderate transient at the beginning and end of each burst and no sustained ringing.

User Comment. In our simulated live-versus-recorded listening test, the speaker system acquitted itself admirably. Having listened to it for some time prior to the laboratory tests, we were not surprised at this. It was obvious from the outset that its sound was essentially musical and well-balanced. The extreme "top end," above 10,000 Hz, where many speaker systems are deficient, was strong and produced the necessary "edge" on wire brush and other sounds in that frequency range. The midrange irregularity could be detected as a slight coloration that we could not completely eliminate with our octave band equalizer. However, it was noticeable

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only during our A-B comparison with the original sound.

Listening to a variety of program material, we were constantly impressed with the smoothness and balance of the system. In fact, the OPC 21 is a feather-weight speaker system that moves into the middleweight class when it comes to sheer sound quality. Of course, one cannot expect a speaker system of the Model OPC 21's size and price to reproduce a deep and powerful bass, nor does it. By slightly reducing the level of the tweeter, however, the balance can be adjusted to avoid a "thin" sound.

Although the Model OPC 21 has no protective fuse and no power recommendations are provided, we feel that it can be used successfully and safely with any receiver or power amplifier that delivers up to about 40 watts/channel of output power. However, fuses are recommended if higher power levels are planned.

The Model OPC is among the more "listenable" small speaker systems.

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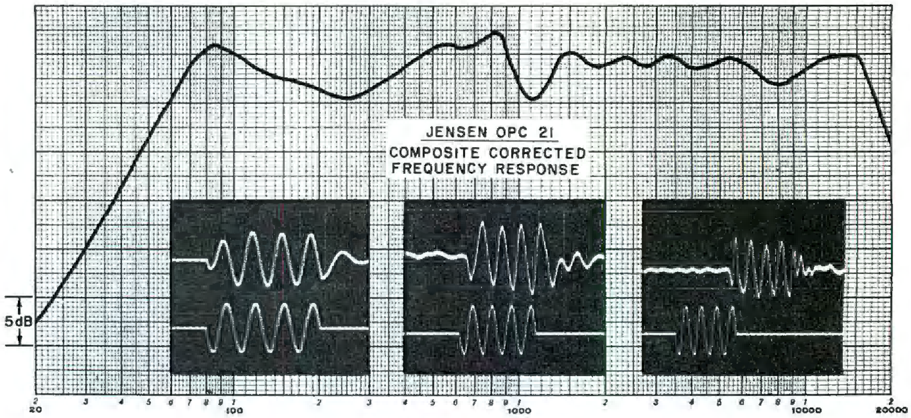
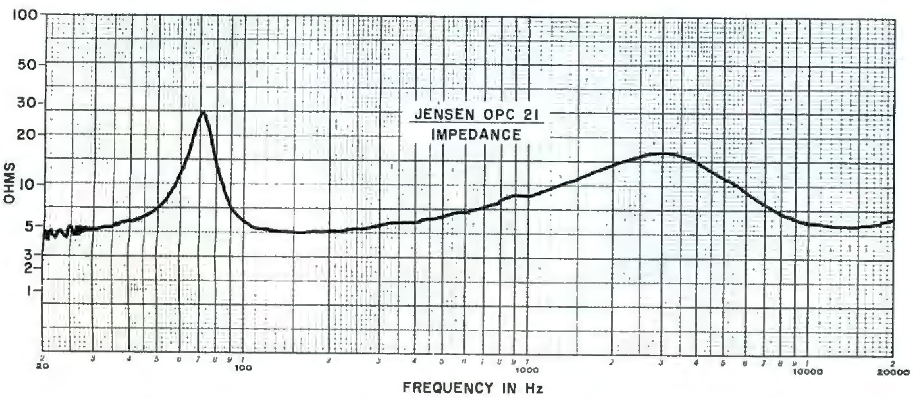


Tone-burst responses are for 100, 800, and 5000 Hz (left to right).



BROWNING GOLDEN EAGLE MARK III AM/SSB CB BASE STATION

Highly versatile system with separate transmitter and receiver.

THE Browning Golden Eagle Mark III is a sophisticated high-quality CB base station with separate transmitter and receiver packages. Both sections employ vacuum-tube technology and are designed to provide complete AM/SSB communication on all Class D CB channels. Separate power supplies for 117-volt ac line operation are built into the transmitter and receiver, permitting either to be used independently of the other if desired. The transmitter is rated at 4 watts output power on AM and 12 watts PEP (peak envelope power) on SSB.

Both the transmitter and the receiver are housed inside the same-size cabinets that each measure 15¼"W × 9"D × 6¼"H (39 × 23 × 16 cm). The transmitter retails for $410 and the receiver for $285.

General Details. The continuously tunable receiver employs double conversion and has one crystal-controlled channel. Standard features include BANDSPREAD tuning, SQUELCH, S meter, switchable AM noise limiter (anl) and fixed SSB anl, AM/LSB/USB selector, RF GAIN control, front-facing speaker, and external headphone/speaker jack. Two unusual features are an AGC disabling switch and a switch that allows selection of internal speaker only, external speaker only, or both speakers simultaneously. There is also a large ON THE AIR light that comes on when the transmitter is keyed.

The transmitter is crystal-controlled on all channels. It has a fine-tune control, selector for AM/LSB/USB operation (with separate indicator lamps for each mode), frequency spotter, and meter with selector switch for monitoring plate current, modulation level in all modes, forward power, and reflected power. The last two are for determining output power and SWR. A detachable desk-stand crystal microphone and all cables for connecting the transmitter to the receiver are included.

The Receiver. The first i-f of 4435 to 4145 kHz is obtained in the receiver by heterodyning the CB signal with a 31.4-MHz crystal oscillator signal. The second conversion to the 455-kHz i-f is obtained by mixing the first i-f with a 4600-to-4890-kHz signal from the tunable variable-frequency oscillator (vfo). Since the vfo operates at a relatively low frequency, a high degree of stability can be achieved. Augmenting this is built-in temperature compensation. In our tests, the stability held within an average of 200 Hz/hr starting

at 75° F (24° C) ambient temperatures. The single-channel crystal (not supplied) is used in place of the vfo.

Two Nuvistor triodes in a cascode circuit make up the r-f amplifier. This type of circuit is often used in vhf and uhf communication equipment to ensure stability with high sensitivity and low noise, which are also enhanced by the use of triode mixers. That this approach pays off well is indicated by our sensitivity measurements of 0.25 µV on AM at 30% modulation with a 1000-Hz test signal and less than 0.1 µV on SSB for 10 dB (S+N)/N.

Selectivity is obtained through the use of a 455-kHz tuned bandpass filter. On AM, this allowed an overall 6-dB response of nominally 300 to 3000 Hz and an adjacent-channel rejection of 50 dB. On SSB, the 6-dB response was nominally 240 to 2400 Hz, and unwanted-sideband suppression was 20 dB at 1000 Hz.

Three pentode i-f stages precede a diode envelope detector for AM, and a pentode product detector is used for SSB. The latter also functions as a self-excited bfo for carrier reinsertion. A series-gate anl is used on AM, while a pulse-diode anl is used on SSB. A triode audio amplifier stage drives a pentode power amplifier output stage that delivered 2 watts at 6% distortion with a 1000-Hz test signal into 8 ohms at the start of negative-peak clipping.

The receiver's triode squelch circuit is agc-activated. It could be set for thresholds of 0.1 to 10,000 µV. The agc held the audio output to within 9.5 dB with an 80-dB r-f input change at 1 to 10,000 µV. The meter registered S9 with a 32-µV input signal.

Other measurements indicated image, i-f, and other spurious-signal rejection figures of 78, 87, and 45 dB, respectively.

The Transmitter. Frequency control for the transmitter is obtained with the aid of 23 crystals in the 16.270-to-16.560-MHz range. On any given channel, the main crystal frequency is mixed with another 5.0485-, 5.047-, or 5.050-MHz crystal-controlled signal for AM, LSB, or USB operation. The mixing process produces a signal of about 21.6085 MHz. The new signal then goes to a transmitter mixer, where the on-channel signal is obtained by combining it with a 5.6465 5.648-, or 5.645-MHz crystal signal for AM, LSB, or USB operation. A fine-tune control is included for this oscillator frequency.

A 12BY7 tube is used as the driver and a 7558 tube as the power amplifier. The power-amplifier stage automatically goes into class C operation on AM or becomes linear (class AB) on SSB. The output circuit is a multi-pi section. A trough-line printed-circuit sensor at the antenna feed is built in to provide the power/SWR functions.

For AM, a dual-triode speech amplifier precedes a dual-triode a-f clipper/driver, followed by a low-pass a-f filter. For SSB, a suppressed-carrier, double-sideband signal is generated by a diode-type balanced modulator and converted to one sideband by a 5.64-MHz crystal filter that precedes the transmitter mixer. A transistorized amplified automatic-level-control (alc) system is used for this mode.

Powering the transmitter from the standard 117-volt ac line, we measured a 4.5-watt AM carrier output at 10% distortion with a 1000-Hz sine-wave signal at 100% modulation. The distortion rose to 18% and heavy negative-peak clipping and carrier breakup occurred when the a-f input was increased by 6 dB. Adjacent-channel splatter was down 50 and 45 dB using 1000- and 2500-Hz test tones, respectively. Otherwise, the audio response was 400 to 4000 Hz.

On SSB the PEP output measured 12 watts with voice signals. The response was nominally 300 to 2800 Hz. Third-order distortion products with the two-tone tests were 34 to 35 dB below the maximum PEP, which was better by at least 10 dB than is usually the case with solid-state transmitters. The alc readily prevented flat-topping that would deteriorate signal quality.

The carrier suppression figure measured 70 dB, while sideband suppression at 1000 Hz was 60 dB. The transmitter's frequency tolerance at the extremes of the fine-tuning control (−VFO+) was within 0.003% on AM and 0.004% on SSB.

User Comment. The system's control knobs are large and easy to grasp and rotate, but their index marks don't extend to the fronts of the knobs, which can make settings difficult to determine under certain lighting and viewing conditions. On the other hand, the illuminated meters and channel dials are large and exceptionally readable under all lighting conditions.

The dial for the receiver includes

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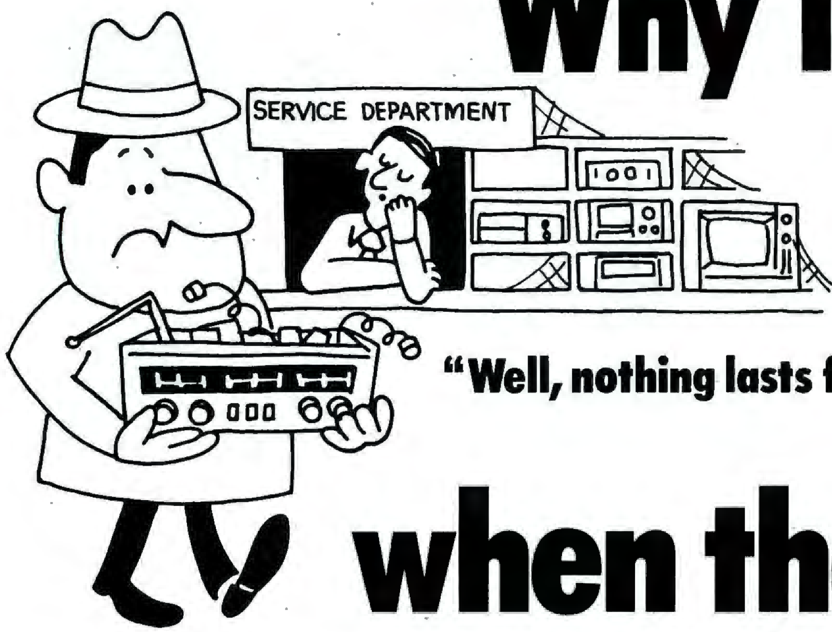

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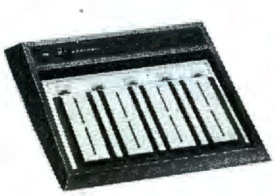
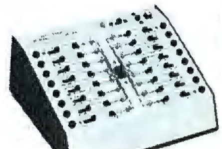


Laboratory breadboard

4-band QRP transceiver



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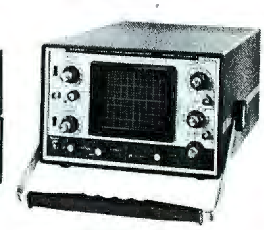

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settings for the radio-control channels (marked RC). Setting the TUNING control to HF enables the receiver to tune in 32 additional channels in the 27,285-to-27,595-kHz range, calibrated on the tuning dial. The dial is accurately calibrated. AM signals appear at the center of the channel numerals, while on SSB, the dial must be moved slightly to one or the other side of the numeral, depending on the sideband in use.

The AM anl was highly effective. It was also good on SSB, but not as noticeably so because SSB's resistance to impulse noise is inherently greater than AM's. The operation of the squelch was very smooth.

The exceptionally high receiver sensitivity enables weak AM and SSB signals to be copied easily.

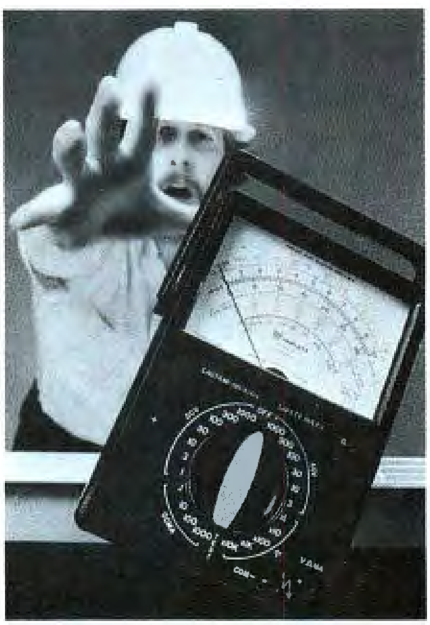
The agc action on strong SSB signals was good. Reducing the setting of the RF GAIN control when strong signals are present can reduce overloading and minimize distortion. Disabling the agc at the same time can also improve sideband suppression under dynamic conditions.

The high quality and performance of the Mark III system make it an ideal base-station setup. Its versatility should make it a CB'er's delight.

CIRCLE NO. 82 ON FREE INFORMATION CARD

TRIPLETT MODEL 60 MULTIMETER

General-purpose VOM emphasizes ruggedness and safety.



Triplett's new Model 60 multimeter is a battery-powered, general-purpose instrument designed to withstand the rigors of heavy use and misuse. In addition, it offers a high degree of protection against electrical-shock hazards. It has ranges for ac and dc voltage, direct current, resistance, and decibels.

The instrument measures 7¼"H × 5¼"W × 3¼"D (18.4 × 13.3 × 8.3 cm) and weighs 2½ pounds (about 2 kg) with one 9- and one 1.5-volt battery installed. Price is $90.

Features. Most service technicians and hobbyists are familiar with the Model 60's pedigree. It evolved from a long line of 20,000-ohms/(dc) volt multimeters. The model 60, however, is distinguished by a number of refinements. For example, its high-impact plastic case and ruggedized meter movement suspension permit the VOM to withstand severe physical shock, such as dropping it onto a hard floor from a 5′ (1.5-m) height, without degrading measuring accuracy. Moreover, accidental burnout of internal components and the meter movement due to incorrect function and/or range setting is virtually eliminated by several internal protection devices. Among these are ⅛- and 1-ampere, 250-volt fuses for normal overload conditions and a 2- ampere, 1000-volt fuse and two zener diodes as backup protection under extreme conditions.

The instrument's ruggedized 45-μA meter boasts a 4½" (11.4-cm) scale length. The movement and scales are contained in a separate protective housing, which in effect physically isolates them from the main instrument case.

In addition to promised longevity, the user obtains a number of welcome operator safety features with the new multimeter. The instrument is completely insulated. Test leads have protective "boots" over the alligator clips that slip onto the basic test probe tips. The test probes themselves are needle sharp for easy penetration of insulation and making good contact with pc board conductors. As mentioned earlier, a 2-ampere fuse offers protection against high-energy faults.

There are eight dc voltage ranges from 0.3 to 1000 volts full-scale in a 1-3 format. (The 0-to-0.3-V dc scale is ob-

tained with the selector switch in the 0.1 DCMA position.) Measurement accuracy at full scale is ±2%, and sensitivity is 20,000 ohms/volt. For ac, there are six voltage ranges, in the same 1-3 format, with full-scale ranges of 3 to 1000 volts. Accuracy on these ranges is ±3% full-scale, while sensitivity is 5000 ohms/volt. The four direct-current ranges provide full-scale measurements of 0.1, 10, 100, and 1000 dc mA. There are also five resistance ranges, in decade steps, covering a range from ×1 to ×10k. When measuring decibels, the range available is from −20 to +52 dB.

A TEST position on the range/function switch allows the user to check the instrument's accuracy and an OFF position protects the meter when not in use. There are only two remaining controls. One is the ohms-adjust potentiometer, and the other is a slide-type switch for selecting polarity.

User Comment. This super-safe, ultra-rugged multimeter will be welcomed by electrical and TV service people who work an instrument "hard" and test a wide variety of electrical and electronic products. With a single combined range/function switch, a single pair of test lead inputs, and a large meter face with red and black scales, the Model 60 VOM is a pleasure to use. A further convenience is its carrying handle, which can also be used as a tilt stand on a workbench.

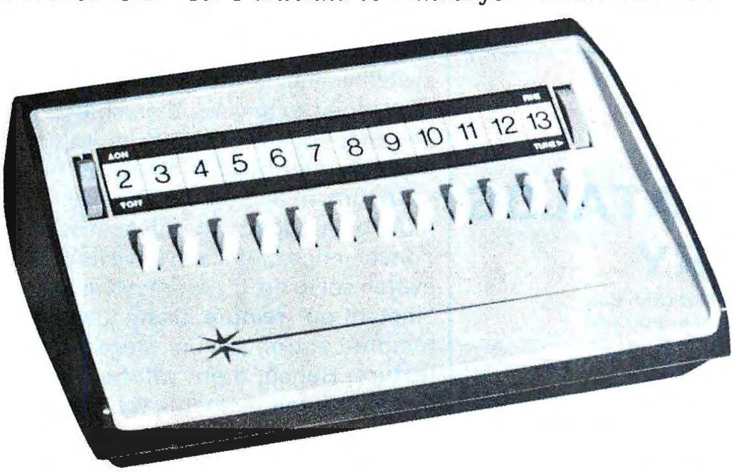
In the event anything ever goes wrong with the multimeter, the user will find it unusually easy to disassemble for servicing. Removing only eight screws completely disassembles the modular-constructed tester. The tester's "guts" are entirely exposed, and everything is accessible for test, troubleshooting, and repair.

Since the VOM doesn't incorporate a dc-blocking capacitor, it's necessary to insert one in series with the test lead to measure ac voltages when a dc component is present. Aside from this, the Model 60 is about as complete a general-purpose multimeter as one could hope for. Of course, its 20,000 ohms/volt impedance does limit its use in very low-voltage solid-state circuits because of loading effects. Also, it cannot measure ac signals in the millivolt range commonly found in small-signal circuits. However, if you do a lot of work on low-resistance circuits where circuit resistance is less than one-fifth of the meter's resistance, and you require portability, ruggedness, and a high degree of operator safety, you should seriously consider the Model 60 multimeter. This is especially true if high-voltage probes and clamp-on alternating-current measuring accessories—both available for use with the multimeter—are desirable for service work.

CIRCLE NO. 83 ON FREE INFORMATION CARD

JERROLD MODEL TRC-12 VHF TV REMOTE CONTROL ACCESSORY

Attaches to TV set's antenna terminals for remote electronic channel changing.



JERROLD Electronics' Model TRC-12 accessory provides TV receiver owners with an opportunity to add remote control of power, channel selection (vhf TV channels 2 through 13 only), and fine tuning without making internal circuit modifications or connections. The solid-state accessory operates without motors, gears, cams, belts, or any other mechanical parts at distances up to 25 ft (6.4 m) from any monochrome or color TV receiver to which it is connected.

The R/C system consists of a converter that attaches to a TV receiver's antenna terminals and an attractive brown-and-tan control unit connected to the converter by a 25' long control line. The TV antenna lead-in cable and receiver's ac power cord connect to the converter's input and switched convenience outlet, respectively. Price is $100.

General Description. To obtain channel changing and fine tuning functions without using mechanical parts, the accessory employs a voltage-variable capacitance (Varactor®) diode oscillator. The oscillator's frequency is changed by depressing one of 12 push-button channel-selector switches, each of which selects a precise dc bias voltage for a given channel. The incoming vhf channel signals are instantly converted to an unused channel in the user's viewing area (usually channel 2 or channel 3). Since the output of the converter is fixed-tuned to one of the unused channels, two models are available: The Model TRC-12-2 is for channel 2, while the Model TRC-12-3 is for channel 3.

The fine-tuning control has a range of about ±1.5 MHz around the nominal TV channel frequency selected. It enables the operator to make minute changes in the Varactor diode's biasing voltage to tune in a clear, sharp picture.

Incoming vhf signals to the converter are filtered. This signal then beats with the variable oscillator's output in a mixer stage to produce an intermediate frequency, which is fed to a second mixer and an i-f amplifier. Beating with a fixed oscillator's output, the signal is down-converted to TV channel 2 or 3 and fed to a final amplifier stage. The output of this stage is fed to the TV receiver's external vhf antenna terminals.

The power supply for the converter and remote-switch control box is in the converter that plugs into a standard 117-volt ac power outlet. The maximum voltage carried to and from the converter and remote-control box is 20 V dc to avoid shock.

The system's specifications include a 54-to-216-MHz input passband, 6-MHz (±1 dB flatness) output channel bandwidth, 4.5-dB minimum and 11 dB maximum gain, and 13-dB nominal noise figure. Power consumption is about 8 watts. The control unit measures 8½" × 5½" × 2½" (21.6 x 14 x 6.4 cm).

User Comment. Installing the Model TRC-12 remote-control system couldn't be simpler. The only tool needed is a screwdriver. Since the converter has 75-ohm input and output impedances, we had to use an inexpensive matching transformer to accommodate our antenna's 300-ohm twin-lead cable. Then we tucked the cord linking converter and control box behind a sofa to keep it out of our traffic area.

After setting the receiver's and converter's fine tuning controls so that picture and sound were adjusted to the centers of their ranges, the fine-tuning control wasn't needed when switching from one channel to another. This is the result of the high stability inherent in Varactor oscillators.

Unlike mechanical remote-control systems, the Model TRC-12 can directly tune to any selected channel in any sequence without having to cycle through intermediate channels.

To turn on and off the TV receiver, it must be plugged into the accessory's convenience outlet and have its power switch set to on. If your receiver has an "instant-on" feature, using it with the remote-control system negates this feature. Hence, there will be a slight delay until the filaments warm up before the picture comes on. Also, the converter is not designed to operate on uhf-TV channels. So, if uhf is important in your reception area, you will have to manually tune these channels at the receiver itself.

The remote-control system did not degrade TV reception. In reality, the boosted signal appeared to improve picture quality on color programs and, from time to time, an out-of-town channel could be received with some "snow," but conditions were still viewable.

In sum, the Jerrold Model TRC-12 remote-control system can be the answer to all those TV receiver owners who bought manual-tune TV receivers and have always wished for remote-control operation.

CIRCLE NO. 84 ON FREE INFORMATION CARD

Test Equipment Scene

By Leslie Solomon

CAN TEST EQUIPMENT BE WRONG?

IT OFTEN happens that a circuit or a piece of equipment has a problem but test gear normally used to locate its source isn't any help. Here are three actual problems we have encountered in which the pertinent test equipment told us everything was OK, but there was a real problem in the circuit operation.

Magnets to the Rescue. While final-testing a vacuum-tube TV receiver, we noted a strange effect on the left half of the screen. We had seen this phenomenon before—it has the appearance of a stream of water running down the screen. Sometimes it looks like just a trickle, other times, its a regular waterfall. The question is what type of test equipment can be used to locate the origin of this effect, and could the equipment tell us how to eliminate the trouble.

The first thing we did, of course, was to test all the tubes, particularly those in the sweep section. They all tested OK. All the voltages and waveforms were within specified limits; and, except for the waterfall, the picture looked good. So, as far as the test equipment was concerned, everything was fine—but our eyes knew better.

In this case, the problem was caused by the electrons "playing games" inside the horizontal sweep output tube. There is no available test equipment to locate this effect (called Barkhausen oscillation). It doesn't show up on a tube tester.

About the only thing to do is change the horizontal output tube and see if the waterfall goes away. If a replacement for the tube is not available, or if a new tube doesn't clear up the trouble, there is one solution. Call on our old friend, the magnet.

In the past, we have mentioned that a magnet is a potential troublemaker around color TV sets, but in this case the magnet becomes a friend instead of an enemy. Obtain a small magnet, and being very careful to avoid high voltages and temperatures, place the magnet against the wall of the horizontal output tube. Move the magnet around until the waterfall either disappears or is reduced until it is no longer conspicuous.

Once the "magic" spot is located, use some form of nonmagnetic holder to keep the magnet against the wall of the tube. Don't use conventional tape as the high bulb temperature will cause the tape to curl up and die.

Invisible Components. Strange things can also happen in the process of checking out homebuilt equipment—especially that of the digital variety. Here again, the standard test equipment won't indicate any trouble. All of the semiconductors are in good shape, the resistors and capacitors are within limits, and the IC chips are getting the required supply of dc. Unfortunately, no matter what the test equipment says, the circuit can still produce some strange readouts—as if there were an invisible circuit component teasing us.

As an example, we had one piece of homemade digital test equipment that we were asked to check out for a friend. Everything tested perfect, but there were all kinds of errors in the display. In this particular case, it turned out that, on the beautiful foil pattern drawn up by the builder, a slender (too thin) foil trace was interwoven around the board to supply the +5 volts to all of the TTL chips. As each IC changed states, current spikes were dashing around this common lead, which was nothing more than a long resistor with taps here and there. The spikes along this line looked like signals to some of the IC's, and they responded to the signals.

After redrawing the foil pattern to thicken the 5-volt line (lowering the resistance and thus the spike level) and including a bypass capacitor between each IC's power input pin and ground (right at the IC), the instrument worked properly. Of course, this same problem could have occurred if the ground line had been too long and thin. The same thing can also happen in point-to-point wiring if a single thin lead is used to supply power (or as a ground).

As another example of invisible components, stray capacitance and its effect on frequency-sensitive circuits should always be kept in mind. Stray capacitance can be present in circuit wiring as well as in tubes and semiconductors.

Half-Bad Transistors. You can't always take the word of test equipment that says a semiconductor is "bad." It may be only "half-bad" and can be used to advantage in many circuits. For example, a transient-damaged high-PRV rectifier diode may be a washout at high voltages, but will work fine as a low-voltage rectifier (if the junction has not been destroyed).

Then there is the case of a transistor with just one bad junction. With a little luck, these half-bad units can be used as conventional diodes, rectifiers, or even good-quality zeners. We have even used some of these one-junction transistors as voltage-variable capacitors. If you happen to have a collection of one-junction silicon power transistors, consider using them as power rectifiers. There is no reason why you shouldn't make use of the one good diode.

While on the subject of transistors, I would like to point out some important facts about physical handling of them. Many people assume that these tough little plastic or metal cans are pretty rugged. Well, they are, but only to a point. One major semiconductor manufacturer claims that a 4½" drop to a hardwood bench produces an acceleration of a few hundred G's; a 30" drop to a cement floor means several thousand G's; and even clipping the leads with a pair of dykes can notch up hundreds of G's. We cannot recall a single case of a failure attributable to the G force. However, since we learned of this possible problem, we have been a little more careful in handling transistors and IC's. Of course, we all know about keeping MOS devices (both transistors and IC's) plugged into conducting foam (usually black) when they are not in a circuit. Don't use ordinary styrofoam (usually white) for this job. ◈

Solid State

A DANDY CIRCUIT

By Lou Garner

IN CASE you are wondering, that word "DANDY" in the title is my own acronym for Discretes Are Not Dead Yet. Although many of today's experimenter and hobbyist projects use integrated circuits, there are hundreds, if not thousands, of exciting and interesting circuits that still use discrete devices (i.e. individual diodes, transistors, and other semiconductor components). There are, in fact, a number of serious experimenters who actually *prefer* to work with discrete devices, feeling that such designs offer more of a challenge to their skills than those using IC's. As one reader expressed it, "I feel I'm *really* assembling a circuit when I work with discretes. Using IC's, except in fairly complex projects, is much like stringing a bunch of black boxes together." Thus, the circuit illustrated in Fig. 1 should provide an interesting (and useful) challenge. It is a voltage-tuned FM broadcast band front end for use with a conventional 10.7-MHz i-f strip. It is also an excellent example of a design using discrete devices. From an engineering applications note from Signetics Corporation (811 East Arques Ave., Sunnyvale, CA 94086), the tuner features a pair of DMOS field-effect transistors and several Varactor diodes. According to the notes, the prototype had a measured sensitivity of better than 1.5 µV for 30-dB quieting, a 50-dB agc range (with an agc voltage of 0 to +10 volts), and an average gain of between 30 and 34 dB, depending on frequency. In tests, the complete FM broadcast band (88 to 108 MHz) was covered as the dc tuning control voltage was varied from about 1.2 to 8.7 volts.

Although similar to conventional MOSFET's, Signetics' DMOS transistors are fabricated with a relatively narrow effective gate channel which reduces parasitic capacitance and raises the drain breakdown voltage. The types specified for the FM tuner are silicon n-channel enhancement-mode devices with integral zener diodes between their gates and substrates. The diodes bypass voltage transients and thus protect the devices against damage during handling and soldering. Half of a double dual-gate DMOS FET (SD6000) is used as an r-f amplifier, with the other half employed as a mixer. A second FET (SD211DE) serves as the local oscillator. The antenna, r-f, and local oscillator coils, *L1, L2* and *L3,* respectively, are tuned by individual fixed and variable trimmer capacitors shunted by dual Varactor diodes in back-to-back configurations. The Varactors' dc control voltage is applied to each pair through separate 82,000-ohm isolation resistors, with a 0.005-µF capacitor serving as a common bypass. As

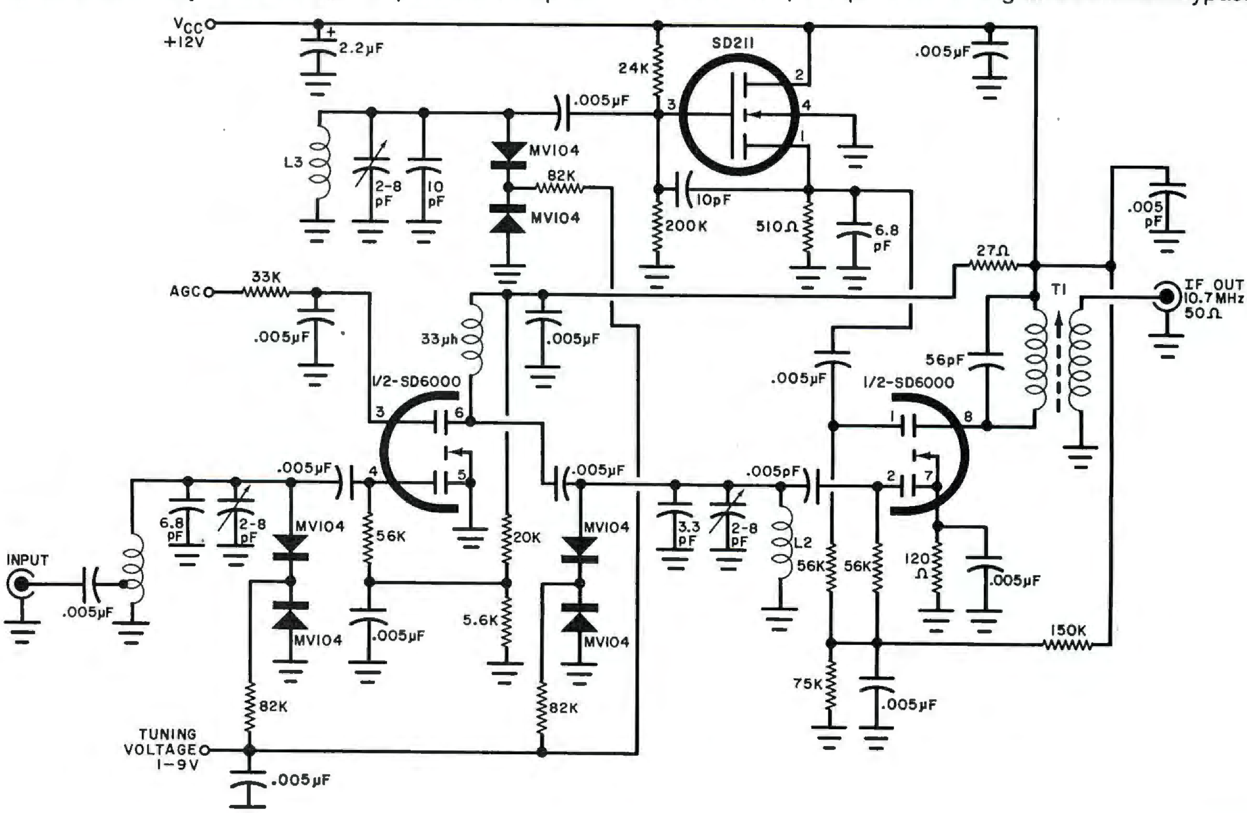


Fig. 1. A voltage-tuned FM broadcast-band front end using discrete devices.

the dc voltage across the diodes is varied, their effective capacitances change, thus tuning their respective circuits to different frequencies. The minimum capacitances, hence the highest frequencies, occur with the higher control voltages, and vice versa. An agc voltage is applied to the r-f amplifier's second gate through a 33,000-ohm resistor, bypassed by a 0.005-µF capacitor. Maximum gain is achieved when the agc voltage is at its maximum (about 10 volts), minimum gain is reached as the voltage approaches zero. Finally, in the mixer stage, one gate is used for the amplified r-f input, the second for the local oscillator's output signal, with both coupled to the mixer through 0.005-µF capacitors.

Except for the hand-wound r-f coils, and i-f transformer, standard components are used throughout the design. The varactor diodes are type MV104. Coils *L1*, *L2* and *L3* are all wound with No. 22 gauge enamelled wire on type T37-12 cores, with *L1* consisting of 5 turns, tapped one turn from the ground end, *L2* consisting of 5 turns, and *L3* 4 turns. The i-f transformer, *T1*, is wound with No. 26 gauge enamelled wire on a *Cambion* type 533-3652-003 form, with the primary consisting of 30 turns, the secondary 2 turns. A 33-µH choke serves as the r-f amplifier's drain load. Capacitors, except for the 2.2-µF electrolytic used as a power supply bypass, should be high-quality ceramic, mica, or plastic film types.

Intended for operation on a 12-volt dc source, the FM tuner can be assembled on a printed circuit board or, with care, on perf board. However, since high-frequency operation is involved, layout may be critical and good technical practice must be observed, with all leads kept short, direct and isolated, and distributed wiring capacitance kept at a minimum. When connected to a standard 10.7-MHz i-f amplifier/discriminator strip, the tuner can be aligned using conventional techniques.

Reader's Circuit. In the majority of metronome circuits using simple R-C timing networks, the tempo (frequency) adjustment has most of its control "squeezed" near one end of the operating range. Seeking to minimize this problem, reader Richard K. Brush (1965 East 3375 South, Salt Lake City, UT 84106) decided to develop his own design for a metronome. His circuit (Fig. 2) features a nearly linear tempo control, loudspeaker output, and, interestingly, discrete devices rather than an IC.

Richard's major improvement is a shift from a voltage variable to a current-controlled charging source for the timing capacitor. Transistor *Q1A* provides temperature compensation for a voltage divider network consisting of *R2*, tempo control *R3* and *R4*. The tempo control's adjustment determines the base bias applied to *Q1B* which, in conjunction with limiting resistor *R1*, serves as a current source for timing capacitor *C1* in the UJT relaxation oscillator. The pulse oscillator's output, developed across base load *R6*, drives the power amplifier, *Q2*, which, in turn, delivers an output signal to a PM loudspeaker. The loudspeaker's voice coil is shunted by *D1*, to dissipate transient voltage peaks developed by sharp current pulses.

To keep costs low, inexpensive components are used. Dual transistor *Q1* is a Poly Paks type 14A 653 or type 2N1132, the UJT is type TIS43, and the output amplifier is a general-purpose npn power transistor, (Radio Shack No. 276-636 or similar). The damping diode, *D1*, is a general-purpose rectifier with a 1-A rating. Timing capacitor *C1* is a 15- or 20-volt electrolytic. An 8-ohm, 3" PM loudspeaker

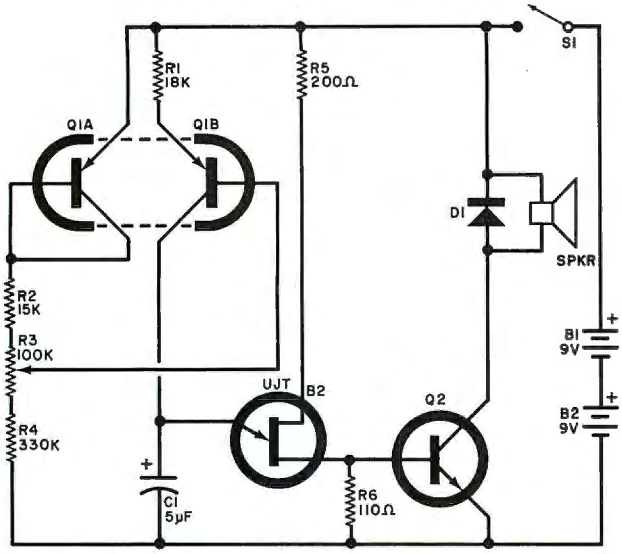


Fig. 2. Metronome circuit has a nearly linear tempo control and loudspeaker output.

was used in the original model, but larger units can be used if preferred. Finally, *B1* and *B2* are standard 9-volt transistor batteries.

Any construction technique can be used for duplicating the circuit. The completed unit, after check-out, can be calibrated using another metronome or a stopwatch.

Richard writes that his original model has a range of 30 to 220 beats per minute, but this may vary with component tolerances. The range can be shifted by using different values for *R1* and *R2*. Current limiting resistor *R1's* value determines the overall tempo, while *R2's* value establishes the minimum-to-maximum ratio. The use of a UJT type other than the one specified may require different values for *R5* and *R6*.

Device/Product News. A pair of logic interface IC's designed to drive 48-volt telephone relays without special protection is available from the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051). Identified as types DS3686, a postive-voltage driver, and DS3687, for negative-voltage relays, both convert standard bipolar and CMOS logic signals to the high-voltage, high-current outputs needed by telephone relays. The devices employ pnp input transistors, providing not only compatibility with TTL, DTL, and CMOS logic, but also a high input impedance for low input loading. In addition, both devices incorporate an internal reference which prevents the type of output-breakdown latching common to ordinary relay drivers and eliminates the need for an external clamping diode to guard against inductive transient voltages. The outputs are Darlington transistors rated at 65 volts and capable of sinking 300 mA per channel.

Not too long ago, you could have safely said that all MOSFET's are low-power devices. That's not true today, for Siliconix, Inc. (2201 Laurelwood Rd., Santa Clara, CA 95054) has introduced the first of a new family of high-power MOSFET's capable of competing with bipolar transistors in both linear and power switching applications. The initial offering in the new "Mospower" family is the VMP-1, a MOSFET with a maximum current rating of 2 A and a power dissipation capability of 60 W. An n-channel device, the VMP-1 is supplied in a TO-3 package, and has a maximum gate voltage rating of 10 V, with a source-to-drain breakdown specification of 60 V. Featuring a minimum transconductance of 200 μmhos and gate threshold levels of from 0.8 to 1.8 volts, the device can be switched directly with standard 5-volt logic signals. The VMP-1's unique power handling capability is made possible by a new fabrication technique employing a V-shaped vertical structure called VMOS.

A new charge-coupled analog shift register that has a variety of applications in video and communications equipment has been announced by the Fairchild Camera and Instrument Corporation (Integrated Circuits Group, 464 Ellis Street, Mountain View, CA 94042). The new device, type CCD311, is a 130/260-bit integrated circuit which performs the function of a wide-range variable analog delay line. Delay is determined solely by the frequency of an external clock signal. Utilizing Fairchild's buried-channel charge-coupled technology, the CCD311 eliminates the need to convert analog signals to digital form for delay within a digital delay system and the subsequent reconversion to analog form. An analog signal voltage can be fed into two charge-injection ports directly to two 130-bit analog shift registers. At the user's option, the CCD311 can be operated either as a single 130-bit unit or, by using multiplexing techniques, as a 260-bit device. The input ports transform the input signals into charge packets which are shifted through the registers by external clock signals. Information in charge packets from the registers is fed into an on-chip output gate, preamplifier and compensation amplifier and the output is a video signal. Capable of operating from frequencies as low as 10 kHz to video rates as high as 15 MHz, the CCD311 can provide delay times from 20 μs to 25 ms simply by varying the clock rate.

An inexpensive monolithic sinewave tone generator suitable for use in radio pagers, data transmission equip-

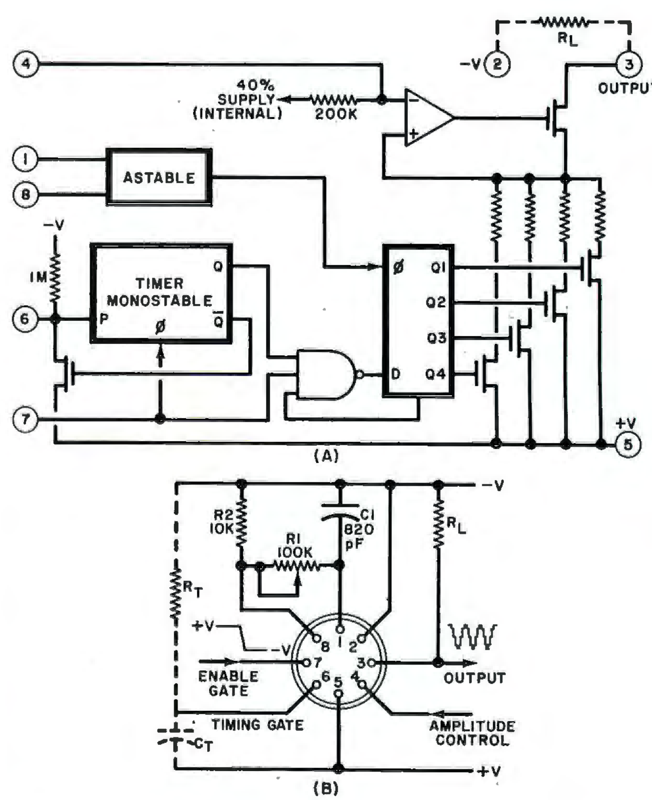


Fig. 3. (A) Block diagram of FX-205.
(B) Typical circuit connections for device.

ment, telephone systems, etc., is now available from the Consumer Microcircuits of America, Inc. (114 East Simmons St., Galesburg, IL 61401). Designated type FX-205, the device's block diagram is given in Fig. 3A, while typical circuit connections are shown in Fig. 3B. The device generates sinewave signals by digital synthesis, using weighted current steps to form the output waveshape. Its frequency is adjustable between 30 Hz and 5 kHz, using an external resistor and capacitor. Output amplitude can be adjusted and the FX-205 also will accept an external pulse signal, converting it to a sine-wave output of corresponding frequency stability. The FX-205 is in an 8-pin TO-99 case. For a limited time, the manufacturer is offering a development kit consisting of two FX-205's and a matching PC board for $10.00 on direct order.

An intriguing display device which should spark the imagination of hobbyists and experimenters has been introduced by Industrial Electronic Engineers, Inc. (7740 Lemona Ave., Van Nuys, CA 91405). Identified as type 301R, the new unit is a gallium-arsenide phosphide 10-dot LED indicator assembled as a linear array in a 12-pin DIP. With a common cathode connection, the device requires 1.6 volts dc at, nominally, 5 mA per dot, delivering an emission brightness (per dot) of 120 μCd. Suitable for use in a variety of displays, including bar graphs, the 301R is compatible with most TTL and DTL circuitry.

Texas Instruments, Inc. (P.O. Box 5474, Dallas, TX 75222) has announced a new micro/minicomputer family with the unique capability of operating with the same "softwear language." This feature makes it possible for users to expand or upgrade their computer systems without discarding software developed for the initial installation. The new compatible family includes the TMS9900 *microprocessor,* the Model 990/4, a complete *microcomputer* on a single printed circuit board, and the general-purpose Model 990/10 *minicomputer.* All members of the family use 16-bit words. The 990/4 microcomputer uses the single-chip 9900 microprocessor as its central processing unit, and is designed for use in a variety of industrial control and data communications applications. The 990/4 also can be used as the central processor for larger computer systems.

Teledyne Semiconductor has announced their 836 quad op amp, which replaces and outperforms the old workhorse, the 741. Small signal bandwidth has been raised to 1.5 MHz (unity gain) and power bandwidth to 20 kHz. Corresponding to this is a typical slew rate of 1.2 V/μs, as compared with 0.5 V/μs for 741-type op amps. Class AB output circuitry is used to eliminate the crossover distortion inherent in class B operation. At maximum output, signal voltage remains symmetrical about ground and swings to within 1 volt of either supply.

The 836's input common-mode voltage range is −15 V to +13.5 V. Since this includes the negative supply, fewer external components are required for biasing in single-supply applications. At ± 15-volt supply voltage and 700 μA per amplifier, total dissipation per package is 84 mW, or only 21 mW per amplifier. The amplifiers are internally compensated, have differential inputs, and share a common bias network and supply inputs. Minimum voltage gain is 25,000. The quad package operates on single-ended supplies from 3 to 30 V, or on split supplies from ±1.5 V to ±15V. Outputs are short-circuit protected. Three versions are offered: the 836C in a 14-pin ceramic or plastic DIP for 0°C to 70°C environments, and the 836B ceramic mil-spec DIP. ◈

COMING UP IN THE MARCH

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THEFT ALARM FOR HAND-HELD CALCULATORS

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PRODUCT TEST REPORTS:

ONKYO TX-220 AM/STEREO FM RECEIVER

MARANTZ 5220 STEREO CASSETTE DECK

MIDLAND CB AT MOBILE TRANSCEIVER

HEATHKIT GB-1201 7-FUNCTION STOP WATCH

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Rogers batteryless receiver type R-563-E, serial no. 5221E, by Rodgers-Majestic Corp., Ltd., Toronto. Early 1940's. Schematic, manual, or any information. William G. Carew, No. 5, 6147 Buckthorn Rd. N.W., Calgary, Alberta, Canada T2K 2Z2.

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National Model NC 125 four-band general-coverage receiver. Any available information. Daryl Rybotycki, 46 Morris Dr., Saskatoon, Sask., Canada, S7L 3T9.

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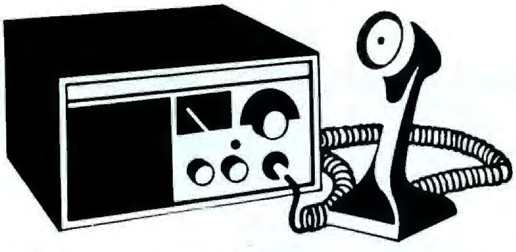

CB Scene

By Ray Newhall

THE FCC AND THE CB'ER

TO AN old-time CB'er who has used more than a dozen rigs since 1959, it's been very interesting to note an important shift in the FCC's attitude toward the Citizen's Radio Service. Evidence of this is obvious; in early 1975, antenna height regulations were eased; in September, restrictions on hobby use were lifted, and inter-station communications were permitted on 21 "free" channels.

At this point, it seems safe to say that the FCC is finally meeting the CB'er at the half-way point. The troublesome, unenforceable regulations have been nearly eliminated from Part 95, and constructive rules have been strengthened to improve the service. Let's briefly review these changes to the Rules and Regulations.

Relaxed Rules.

- Omnidirectional antennas can be raised to 60 feet above ground. All other antenna restrictions remain unchanged. Note these cover receiving as well as transmitting antennas.
- All channels except channels 9 and 11 can be used for communications between units of different stations.
- Non-substantive (hobby) use is permitted on all "free" channels.
- Only *your* call letters need be broadcast at the beginning and end of each transmission. Handles (Chief Frog, etc.) can be used additionally for ID purposes, but are not substitutes for call letters.
- The 5-year license fee has been reduced from $20 to $4.
- Communications are *still limited* to 5 minutes duration, but waiting time between communications has been reduced to one minute. CB'ers can now relay messages for other operators up to a total distance of 150 miles.
- Uses of channel 9 which provide assistance to travellers have been clarified to include boats, aircraft, etc.

Added Or Reinforced Reg's.

- Channel 11 has been designated a "Call and Switch" channel, which can be used as a common hailing channel. Once contact is established, the operators must switch to another channel.
- Each CB'er must transmit his own call letters at the beginning and end of each transmission. There is a strong indication that failure to use call letters will be considered evidence that the operator is not licensed. Stringent enforcement of station ID is expected, with intensive efforts made to identify and prosecute unlicensed operators.
- No linear amplifiers can be manufactured, sold, or used. The presence of a linear on the premises will be considered "de facto" evidence of its use. No modulation boosting devices (mike amplifiers) can be used if they are capable of driving the transmitter beyond 100% modulation. Note that all type-accepted transmitters built since May 1974 must contain modulation limiting devices, and must not modulate the carrier with audio information extending above 3000 Hz.
- CB radio must not be used in any connection with acts contrary to any Federal, state, or local law or ordinance.
- No CB communications can contain obscene, indecent, or profane words, language, or meaning. No music, whistling, or audio tones (other than tone bursts for selective squelch) can be transmitted. No modulated or unmodulated carrier or SSB signal can be transmitted with the intention or effect of "jamming" the frequency or attracting attention (such as "Goony birds"). It is illegal to intentionally interfere in *any* way with the communications of another station.
- *Never* transmit the word "MAYDAY" or any other international distress signal unless there is a confirmed, "grave and imminent danger to life or property." Penalties for false distress signals range from heavy fines to severe jail sentences, or both!

For about 18 years many CB'ers

have questioned the motives for the restrictive provisions of Part 95. But now (at last!) we have a set of relaxed rules we can live with.

These rules are also just in that they provide a legal basis to protect the majority of us who want to use the Citizens Band legitimately. They will make life difficult for the few rude operators who claim solitary possession of the channels for their personal pleasure. The "don'ts" have been clearly defined. We all must admit that these restrictions are aimed only at curbing the gross abuses of the CB pirates who tend to make the band offensive and useless.

By simplifying the rules, the FCC seems to be saying that it intends to enforce them as completely as possible. One major area of concentration will be illegal linears and mike boosters. Every day, both we and the FCC monitors can hear splatter, distortion, and bleedover caused by the use of such devices. Persons who use them obviously have no concern for others. Nor do they have the knowledge (in my opinion) that every word they say can be heard on at least three, seven, or in extreme cases, all 23 channels. Not to mention their neighbors' radios, TV receivers, etc.!

All legitimate CB'ers should applaud these efforts to clear up the band. I, for one, will keep my Congressman and Senators aware of the Commission's need for adequate funding of the enforcement program. I hope you'll do the same!

Is There More to Come? Yes, there is. There are possibilities of nearly doubling the number of Class D channels, although some of the new channels may be restricted to SSB only.

But equally important are the most recent proposals for an additional class of the Citizens Radio Service in the vhf region, around 200 MHz. It would be an FM band with an authorized transmitter power output between 10 and 25 watts, not unlike the vhf/FM marine band now in use.

The EIA first suggested a "Class E" Citizen's Band in 1968, and petitioned the FCC to authorize 80 channels on frequencies which are part of the then little-used 220-to-225 MHz amateur band. This service would enjoy the benefits of FM operations—noise immunity and capture effect (the tendency of an FM receiver to "lock on" to the most powerful signal on channel and reject all others).

The nature of vhf signal propagation would restrict most communications to a 15-to-20 mile "line-of-sight" range. Over these distances, 25 watts of output power would provide reliable communications at almost any time of the day, season of the year, or point in the 11-year sunspot cycle.

However, the Commission has not acted on the Class E proposal for nearly seven years, due in part to the objections of radio amateurs. During that time amateurs successfully established many repeater networks on the band under the theory of "protection of property." In 1975, the FCC finally issued a counterproposal to the EIA petition, suggesting a 40-channel band just below 220 MHz.

However, no such service has actually been set up. In 1975, the Office of Telecommunication Policy, a White House agency set up in recent years, requested that the FCC act quickly to establish the Class E band. Unfortunately, the Commission has not yet made any firm decisions on the Class E proposal for a variety of reasons. Of major importance is the fact that Canada and Mexico have not agreed to the change thus far. Are both D and E needed? Yes, most definitely—at least for the next several years. Class D is a popular, low-cost service, especially useful for the protection and safety of those using the interstate highways, as well as small boat users. Most of all, Class D is an established service, a known quantity.

Class E, on the other hand, will be at an initial disadvantage. Vhf transceivers will probably cost about twice as

much as those for the 11-meter band with similar features. At first, the band will be empty. Despite higher initial cost, vhf rigs will yield far more reliable "point-to-point" communications than their hf counterparts. The very emptiness of the band will stimulate interest.

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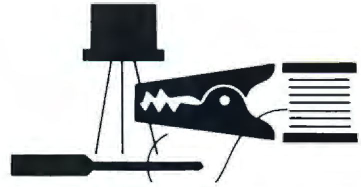

Tips & Techniques

DOG-BONE WRENCH IS RIGHT TOOL FOR FRONT-PANEL COMPONENTS

Rotary switches, potentiometers, and other components that mount on panels must be securely tightened. Most experimenters and hobbyists, unfamiliar with proper shop practices or too much in a hurry to get the job done, reach for ordinary pliers to tighten the nuts holding these components. The result is that the pliers often slip and gouge the panel. The obvious moral is to use the right tool for the job. But what is the right tool in this case? The answer is the inexpensive "dogbone" wrench. It has hex openings sized to accommodate all common locknut sizes.

—Raymond F. Arthur

MEDICAL/DENTAL TOOLS

Some medical and dental tools can be put to good use on an electronics workbench. As a typical example, the dental inspection mirror is just as handy in inspecting electronic equipment chassis as they are for inspecting teeth. Need a hands-free heat sink when soldering a component into place in a circuit? Almost made-to-order for heat-sinking jobs like this is the medical hemostat or clamp. Equipped with a positive locking action that keeps its jaws clamped shut, the hemostat also comes in handy as a general holding tool. Such tools are available from certain electronics parts outlets, but if you can't find them locally, try your local medical/dental supply house.

—Michael Rosenfield

MASKING TAPE MAKES HANDY NUT HOLDER

When assembling a kit, it can be very difficult to start a screw when a nut must be held on the other side of a chassis. Using a 3- or 4-inch (7.5- or 10-cm) piece of masking tape can simplify matters. Wrap the tape (adhesive side out) around the tip of the index finger. Place the nut on the adhesive side of the tape and hold it behind the hole.

—Harry Gondo

HAND DRILL SIMPLIFIES MAKING TWISTED-PAIR CABLE

If you have ever tried to make by hand a twisted-pair cable more than a few inches long, you know how tedious the job can be It needn't be. The next time you need twisted-pair cable, cut two pieces of hookup wire to the same length, clamp one end of each in a vise, and chuck the other ends into a hand (not electric power) drill. Then just crank away on the drill. In a matter of minutes, you can make several feet of twisted-pair cable.

—John Bretthauer

Electronics Library

GUIDE TO HIGH FIDELITY

This book (prepared by The Institute of High Fidelity) presents the advantages of component high-fidelity systems (stereo and 4-channel) and some points to consider when shopping for such equipment. Popular program sources, including discs; cassette, cartridge, and open-reel tapes, and FM radio, are discussed. Various aspects of preamplifier and power amplifier operation are explained—including equalization, impedances, power output, amplifier controls and specifications. Separate chapters are devoted to loudspeakers and headphones. The final chapter explains how to assemble a hi-fi system from components. Appendices include typical component specifications and a glossary of high-fidelity terms.

Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46206. 174 pages. $4.50.

GE POWER TRANSISTORS USERS GUIDE, SECOND EDITION

This updated book contains practical information on circuit applications, handling and mounting, and reliability prediction. Covered is GE's line of power semiconductors, which includes complementary pairs, Darlingtons, and high-voltage transistors, in both metal and plastic cases. General information is given on pellet construction, critical parameters, thermal considerations and operational cycling.

Published by General Electric Corp., Semiconductor Products Dept., Syracuse, NY 13201. 120 pages (8½" × 11"). Soft cover.

SERVICING MAGNAVOX FOR 1974-1975

by Stan Prentiss

This latest addition to Audel's servicing series covers Magnavox's consumer electronics line for the appropriate years. Included are color and monochrome television receivers, with separate chapters devoted to TV portables, radios and the Odyssey TV game simulator, and tape players/recorders and amplifiers. Special servicing information is contained in two chapters. One shows the wide range of tests possible with an oscilloscope, and the other gives troubleshooting tips and waveforms for the new T995 TV receiver.

Published by Theodore Audel & Co., Div. of Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46206. 473 pages (8½" × 11"), not including foldouts. $12.95 soft cover.

Experimenter's Corner

By Forrest M. Mims

TTL SEQUENCE GENERATOR

BUILDING a TTL sequence generator is an excellent way to learn more about digital logic IC's. Besides being a valuable teaching tool, this handy circuit has dozens of practical applications, ranging from a programmable square-wave generator to an unusual LED flasher. You can also program a sequence generator to synthesize electronic music or to turn lights and radios on and off at "random" when you are away. The operation is versatile enough to fool potential burglars into thinking someone is home.

Figure 1 is the block diagram for a basic ten step (0-9) sequencer which uses a simple clock and a couple of TTL chips. All three chips for the sequencer can be purchased for well under $2.50 from many of the parts suppliers who advertise in the back of this magazine.

Operation of the sequencer is straightforward. The clock delivers a string of pulses to a 7490 decade counter which counts the incoming pulses and supplies a running total in binary form (often called binary coded decimal or simply BCD) to a 7441 BCD to decimal decoder. The 7490 contains four cascaded flip-flops. Only one of the ten outputs of the 7441 is activated for each of the BCD equivalents of 0-9. The 7441 does all this with 7 gates containing a total of 17 transistors, 26 diodes, and 29 resistors. There is also a single transistor at each output to provide interface buffering.

Now that you know how the sequence generator works, take a look at the complete circuit diagram in Fig. 2. The clock is a 555 timer IC connected as an astable (free-running) multivibrator. You can use a unijunction transistor oscillator or a simple TTL clock made from inverters, but the 555 provides a very wide range of timing periods and is ideally suited for use in a sequence generator. Note that both the 7490 and 7441 are self-contained chips which don't require any external components.

The scope photos in Figs. 3 and 4 show the two simplest operating modes of the sequencer. In Fig. 3, the timing pulses from the 555 clock are shown in the top trace, and the output from *one* of the ten 7441 outputs is shown in the bottom trace. Note how one 7441 pulse occurs for every ten clock pulses. In Fig. 4, two outputs from the 7441 (pins 16 and 8) have been shorted together to give two output pulses separated by a single clock period. By shorting pin 15 to pins 16 and 8, a third pulse will be produced between the existing two. The result will be a single pulse having a total width of three clock periods.

Different Outputs. Most of you are probably way ahead of me by now and realize you can short various combinations of output pins to produce different square-wave outputs.

To convert the basic sequencer into an odd-sequence LED flasher (guaranteed to attract attention) just connect two or more LED's to various outputs or combinations of outputs. Connect the anode leads of the LED's to the positive supply through 370-ohm resistors (to limit current and pro-

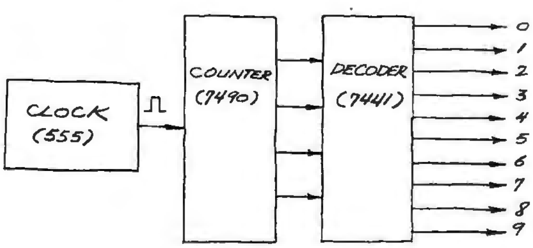

Fig. 1. Block diagram of sequence generator.

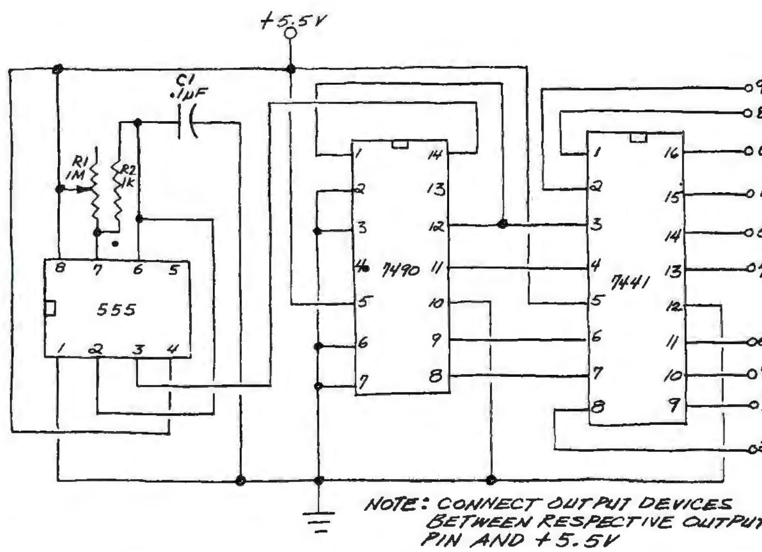

Fig. 2. A 555 timer is the clock and two 7400 IC's count and decode its output.

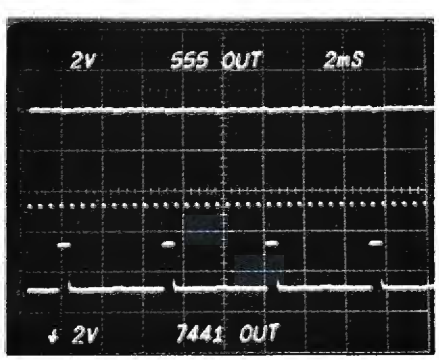

Fig. 3. 555 clock pulses and single output from the 7441.

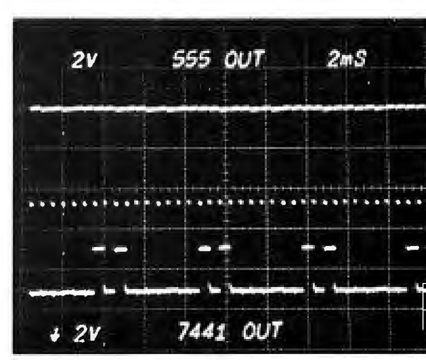

Fig. 4. Clock pulses (top) and output from two pins of 7441.

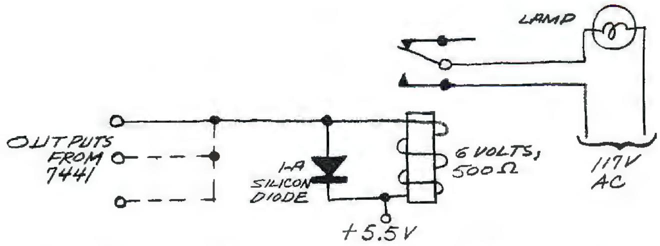

Fig. 5. As many as 10 relays can be used to control various home appliances.

tect the LED's) and the cathode leads to the appropriate output pins. Increase *C1* (Fig. 2) to about 5 µF to slow down the clock and make the individual flashes visible.

For easy programming, use one or more rotary switches to short various outputs together. You can make interesting effects by mounting the LED's in a geometric shape or outline. Try arrows, circles, and zig-zags for best results. Incidentally, this circuit delivers about 10 mA to each LED. If more current is needed for your LED's, use 185-ohm series resistors for 20 milliamperes.

Burglar Deceiver. Now that you know how to build both a programmable square-wave generator and a fairly fancy LED flasher, how do you "randomly" switch your house lights and perhaps a radio on and off to keep the burglars away? Simply increase *C1* to 50 µF and *R1* to 10 megohms to get a clock cycle of about ten minutes for a total timing period of 100 minutes. Then connect outputs from the 7441 to suitable relays whose contacts control lamps or radios in various rooms of your house. Install a 1-A rectifier diode across each relay coil as shown in Fig. 5.

Here's a table for a possible deception arrangement you can adapt to your own use:

Timing Cycle	7441 Pins	Appliance(s)
0	16	Kitchen Light
1	15	Kitchen Light
2	8	Living Room Lamp/Radio
3	9	Living Room Lamp/Radio
4	13	Living Room Lamp/Radio
5	14	Bedroom Lamp
6	11	Bedroom Lamp
7	10	Bathroom Lamp
8	1	Bedroom Lamp/Radio
9	2	Bedroom Lamp/Radio

(Repeat)

Make sure the relays you choose are properly rated or your burglar deceiver will fool no one but you! For example, let's assume you use relays with contacts rated for 1 ampere at 117 volts. Most household appliances are rated according to power consumption, so you will have to determine what power level these contacts can safely handle. Since P=EI, this relay will switch up to 117×1 or 117 watts. Of course, if you want to use solid-state switching, the 7441 outputs can drive triacs, but be sure to observe current and PIV ratings.

If you like this burglar deceiver, don't be afraid to experiment with the timing cycles and sequences. For example, try increasing *C1* to get longer timing cycles. Also, consider using a light-activated relay to turn the circuit on at night and off in the daytime. Finally, be sure to install the circuit in a case along with a 5.5-volt power supply (more about this topic in a future column). Use good wiring between the relays and the appliances they control or you may have a fire hazard. ◈

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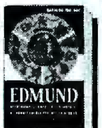

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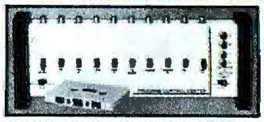

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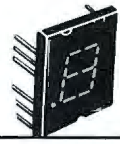

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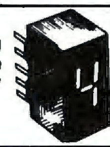

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Dual section, 2000 MFD and 1500 MFD at 30 WVDC Twist Lock. 79c ea. 3 For $2

NATIONAL VOLTAGE REGULATOR

Like 7805. 5VDC - 1 AMP output. Has TO-220 plastic power tab - 99c

IN4148 COMPUTER DIODES

Same as IN914. Factory prime. 20 for $1

FULL WAVE BRIDGE

By G. I. 1.5 AMP 800PIV - 75c

2N706A 400MHZ. TRANSISTORS

Silicon NPN. 1 WATT. TO-18 Case. 5 For $1

LARGE SIZE LED LAMPS

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MC1469R. TO-66 9 Lead package. For 3 TO 30V Outputs. Provides 600 MA direct output or more by using an external power transistor. Reg. catalog $4 ea. With specs. $1.95 ea.

MOTOROLA POWER DARLINGTON

$1.99

MJ3001 - NPN - 80 Volts - 10 Amps - HFE 6000 typ. To-3 Case. Ideal for power supplies, etc. We include a free 723 regulator w/schematic for power supply with purchase of the MJ3001. You get the two key parts for a DC supply for only $1.99. Regular catalog price for the MJ3001 is $3.82

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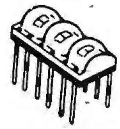
LM309K

TO-3 Case, 1 AMP 5 VDC Voltage Regulator. Brand New By National $1.19



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Like Litronix DL-33 3 MAN-3 style readouts in one package. Factory new units Designed for calculators. Special — $1.39 (3 Digits)

LITRONIX DL707 READOUTS
.30 IN. CHAR. Common Anode.
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The newest and easiest to use chips available today. Made by famous US mfg. All are 28 pin DIP. Features: direct LED segment drive, low power consumption, internal keyboard debounce, internal clock oscillator, single supply voltage, internal keyboard encoding, and floating decimal point. Does not require many external components as do older types like CT5001, 5002, 5005, etc. We offer the most sophisticated functions for the lowest price anywhere.
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Plastic version of 2N3055. NPN Silicon. 90 Watts 15 Amps. SPECIAL — 69c

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Computer on a chip. 8 Bit Parallel CPU. Can address 16k x 8 bits of memory. With specs. Factory tested units.
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Coil is 500 OHM. SPST-No. $1.49 Sub-Mini.

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7406-24c	7474-37c	74157-99c
7808-16c	7475-65c	74161-99c
7410-16c	7476-39c	74163-1.19
7413-49c	7483-85c	74164-1.89
7420-16c	7490-69c	74165-1.49
7427-24c	7492-75c	74174-1.29
7430-16c	7493-75c	74175-1.39
7437-39c	7495-75c	74181-2.75
7438-35c	7496-75c	74192-1.25
7440-16c	74121-38c	74193-1.25
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The most popular clock chip around. We made a huge special purchase of factory fresh, prime units. Lowest price in USA. 24 Pin DIP. 4 or 6 Digits. With Specs.
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New. Litronix 727. Dual. Perfect for giant clocks, etc.
$3.95 each (2 DIGITS)

JUMBO LED READOUT

Twice the size of regular readouts. .65 inches. Like Litronix DL747. Outperforms and easier to read than SLA-3, only 20 MA per segment. Our best readout for digital clocks.
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1000 MFD 16VDC upright style.
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IN4148 DIODES

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MAN5 — GREEN — $1.29
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565A by Signetics. Extemely stable. High linearity, wide frequency range. TTL compatible. Perfect for tone decoders, FSK, SCA receivers, frequency multiplication and division — 99c
WITH SPECS

FLOURESCENT READOUT TUBES

7 Segments. Blue-Green in color. Mfg. by ISE. #DG8F. The most popular display used in many imported clocks and calculators. Perfect for use with MM5316 clock chips.
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2N4443 8 Amp 400PN, Plastic Power Case. 69c

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75491 Quad segment dr. — 29c
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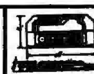

6 DIGIT LED READOUTS

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SUPER SPECIAL $1.29 ea 3 for $3

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1 AMP 400PIV SPECIAL 15/$1

7805 STYLE REGULATORS

TO-220 Plastic Case 5VDC Regulator. Brand New by National — 99c

FACTORY NEW LED'S

Jumbo Red-Like MV5024-8/$1
Jumbo Green-Like MV5222-5/$1
Jumbo Yellow-5!$1
Mini Red-Like MV50-10!$1

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Mfg. by Contralab for Ford car radios. Each module contains 2 transistors plus other components. These modules were used as audio pre amps. We include specs. — 4 For $1

TTL IC ASSORTMENT

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200 PCS FOR $3.95

FM TRANSFORMERS

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TANTALUM CAPS

By Sprague. 4.7 MFD 10 VDC. Axial Leads. Perfect for timers.
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TRANSFORMER SPECIAL #1

Miniature size. Primary 115V AC Secondary 11V AC No Load. 8V AC with 400 MA Load. Perfect for clocks or calculators or small power supply. 99c

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SN7430N	.26	SN74100N*	1.00	SN74187N	6.00
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MANY OTHERS AVAILABLE ON REQUEST
20% Discount for 100 Combined 7400's

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CD4007	.25	CD4040	2.45	74C73N	1.50
CD4009	.59	CD4042	1.90	74C74	1.15
CD4010	.59	CD4044	1.50	74C90N	3.00
CD4011	.25	CD4046	2.51	74C95N	2.00
CD4012	.25	CD4047	2.75	74C107N	1.25
CD4013	.47	CD4049	.79	74C151	2.90
CD4016	.56	CD4050	.79	74C154	3.00
CD4017	1.35	CD4051	2.98	74C157	2.15
CD4019	.55	CD4053	2.98	74C160	3.25
CD4020	1.49	CD4060	3.25	74C161	3.25
CD4022	1.25	CD4066	1.75	74C163	3.00
CD4023	.25	CD4069	.45	74C164	3.25
CD4024	1.50	CD4071	.45	74C173	2.60
CD4025	.25	CD4081	.45	74C193	2.75
CD4027	.69	74C00N	.39	74C195	2.75
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LM300H	.80	LM380N	1.39	LM1496N	.95
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LM301CN*	3/1.00	LM381N	1.79	LM2111N	1.95
LM302H	.75	LM382N	1.79	LM2901N	2.95
LM304H	1.00	NE501K	8.00	LM3065N	.69
LM305H	.85	NE510A	6.00	LM3900N	.55
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LM320K-15	1.35	LM710N	.79	75492CN	.89
LM320K-5	10.50	LM711N	.39	75494CN	.89
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LM351CN	.65	LM1304N	1.19	CA3091	8.25
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Includes monolithic function generator IC, PC board, and assembly instruction manual

XR 2206KB — SPECIAL $27.95
Same as XR 2206KA above and includes external components for PC board

TIMERS		WAVEFORM GENERATORS	
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Astrisk Denotes Items On Special For This Month

Special Requested Items

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RC4195	± 15V Track Reg	3.25	4024P	2.25	8263	5.95	LM3909	2.25
F9368	Decoder	3.95	2513	11.00	8267	2.75	MM5320	19.95
LD110/111	DVM Chip Set	28.00	2518	7.00	8288	1.15	74279	.90
CA3130	Super CMOS Op Amp	1.49	2524	3.50	8826	3.00	4072AE	.45
MC1408L7	A/D	9.95	2525	6.00	8880	1.35	4511AE	2.50
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XC220 4/$1

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XC556Y 4/$1
XC5560 4/$1

.085" dia.
MV50
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6/$1

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TYPE	POLARITY	HT		TYPE	POLARITY	HT	
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MAN 2	5 x 7 DOT MATRIX	.300	3.95	DL707	COMMON ANODE	.300	$1.50
MAN 3	COMMON CATHODE	.125	.39	DL747	COMMON ANODE*	.600	1.95
MAN 4	COMMON CATHODE	.187	2.50	DL750	COMMON CATHODE	.600	2.49
MAN 7	COMMON ANODE	.300	1.50	DL33B	COMMON CATHODE	.110	1.95
MAN 7G	COMMON ANODE-GREEN	.300	2.50	FND70	COMMON CATHODE	.250	.50
MAN 7Y	COMMON ANODE-YELLOW	.300	2.50	FND503	COMMON CATHODE	.500	1.75
MAN 72	COMMON ANODE	.300	1.50	FND507	COMMON ANODE	.500	1.75

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	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.43
16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)

14 pin	$.27	.25	.24	28 pin	$ .99	.90	.81
16 pin	.30	.27	.25	36 pin	1.39	1.26	1.15
18 pin	.35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$. 70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
				40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
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18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea.	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	1/4 WATT 5% = 50 PCS.
ASST. 2	5 ea.	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	1/4 WATT 5% = 50 PCS.
ASST. 3	5 ea.	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	1/4 WATT 5% = 50 PCS.
ASST. 4	5 ea.	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	1/4 WATT 5% = 50 PCS.
ASST. 5	5 ea.	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5% = 50 PCS.
ASST. 6	5 ea.	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	1/4 WATT 5% = 50 PCS.
ASST. 7	5 ea.	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	1/4 WATT 5% = 50PCS.

ALL OTHER RESISTORS FROM 2.2 OHMS 5.6M AVAILABLE IN MULTIPLES OF 5 ea 5-25 PCS: .05 ea. 30-95 PCS: .04 ea. 100-495 PCS: .03 ea. 500-995: .027 ea.

14 PCS. POTENTIOMETER ASSORTMENTS

ASST A 2 ea 10 OHM 20 OHM 50 OHM 100 OHM 200 OHM 250 OHM 500 OHM
ASST B 2 ea 1K, 2K, 2.5K, 10K, 20K, 25K, 50K
ASST C 2 ea 50K, 100K, 200K, 250K, 500K, 1M, 2M

$9.95 Per Asst.

Each assortment contains 14 pcs of 10 turn pots. All pots are available in single unit quantities. $.99 ea.

PRIME INTEGRATED CIRCUIT ASSORTMENTS

ASST 8	3 ea	SN7400 SN7410	7401 7430	7402 7438	7403 7440	7404 7472	SSI TTL	$5.95 ASST
ASST 9	2 ea	SN7447 SN74145	7490 74175	7491 74180	74100 74191	74121 74193	MSI TTL	$9.95 ASST
ASST 10	2 ea	CD4001 CD4016	4002 4017	4011 4019	4012 4023	4013 4030	CMOS	$7.95 ASST
ASST 11	2 ea	LM301T LM311T	301N 565T	302T 567T	307T 741T	309K 741N	LINEAR	$10.95 ASST

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax
Write for FREE 1976 Catalog — Data Sheets .25¢ each

JAMES

P.O. BOX 822, BELMONT, CA. 94002
PHONE ORDERS — (415) 592-8097

74LS00 TTL

74LS00	.39	74LS55	.39	74LS151	1.55
74LS02	.39	74LS73	.65	74LS153	1.89
74LS03	.39	74LS74	.65	74LS157	1.5S
74LS04	.45	74LS75	.79	74LS162	2.25
74LS05	.45	74LS76	.65	74LS163	2.25
74LS08	.39	74LS83	2.19	74LS164	2.25
74LS10	.39	74LS86	.65	74LS181	3.69
74LS13	.79	74LS90	1.25	74LS190	2.85
74LS14	2.19	74LS92	1.25	74LS191	2.85
74LS20	.39	74LS93	1.25	74LS192	2.85
74LS26	.49	74LS95	2.19	74LS193	2.85
74LS27	.45	74LS96	1.89	74LS194	2.25
74LS28	.49	74LS107	.65	74LS195	2.25
74LS30	.39	74LS112	.65	74LS257	1.89
74LS32	.45	74LS132	1.55	74LS260	.55
74LS40	.49	74LS136	.65	74LS279	.79
74LS51	.39	74LS138	1.89	74LS670	5.95

DPST
C & K ROCKER SWITCH
Dim: 1"x1"x¼"

They are rated at 125 Vac @ 5A. They are excellent in applications such as Microcomputer Panel Switches **$.69**

MINATURE TOGGLE

DPDT				JMT	1	2-9	10-29	30-99
	ON	OFF	ON	221	3.05	2.65	1.97	1.78
	ON	NONE	ON	223	2.65	2.26	1.68	1.51
	ON	OFF	ON	121	2.35	1.95	1.43	1.30
	ON	NONE	ON	123	2.05	1.65	1.21	1.10

PUSH BUTTON

SPDT — SERIES PB, PB1

	Model Number	1 Each	2-9	10-29	30-99
Maintained Action Switch — Push To Make Contact And Push Again To Reserve Action	PB-123	$2.35	$1.95	$1.47	$1.30
Momentary Action Switch — Normally Open or Normally Closed (For N C circuit use terminals 2 & 1, for N O, 2 & 3; for N C and N O, 1,2,&3	PB-128	$2.35	$1.95	$1.47	$1.30

Quanity net prices
5 AMP RATINGS

THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY
SF – Front Mount SR – Rear Mount

Part No.	Description	Price
SF 12	Single Pole 10 Position	$2.50
SR 12	Decimal	3.00
SF 21	10 Position BCD only	2.50
SR 21		3.00

Ordering: Order desired switch or switches and add necessary accessories for your particular application

SERIES SF Front Mount Assembly ($11.78)
SERIES SR Rear Mount Assembly ($13.78)

ACCESSORIES

Part No.	Description	Price	Part No.	Description	Price
SF EP	End Plate (Pair)	$.50	SR EP	End Plates (pair)	$.50
SF DP	Divider Plate (each)	.40	SR DP	Divider Plate (each)	.40
SF BB	Blank Body (each)	.40	SR BB	Blank Body (each)	.40
SF HB	Half Body (each)	.40	SR HB	Half Body (each)	.40

8 POSITION ROTARY SWITCH

These switches are a 7 position, one position open, rotary switch enclosed in a TO-5 can. They have a standard 8 pin configuration and will mount perfectly on printed circuit board. **$.99 ea.**

ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
IN746	3.3	400m	4 1.00	IN4003	200 PIV	1 AMP	12/1.00
IN751A	5.1	400m	4 1.00	IN4004	400 PIV	1 AMP	12/1.00
IN752	5.6	400m	4 1.00	IN3600	50	200m	6 1.00
IN753	6.2	400m	4 1.00	IN4148	75	10m	15 1.00
IN754	6.8	400m	4 1.00	IN4154	35	10m	12 1.00
IN965B	15	400m	4 1.00	IN4734	5.6	1w	28
IN5232	5.6	500m	28	IN4735	6.2	1w	28
IN5234	6.2	500m	28	IN4736	6.8	1w	28
IN5235	6.8	500m	28	IN4738	8.2	1w	28
IN5236	7.5	500m	28	IN4742	12	1w	28
IN456	25	40m	6 1.00	IN4744	15	1w	28
IN458	150	7m	6 1.00	IN1183	50 PIV	35 AMP	1.60
IN485A	180	10m	5 1.00	IN1184	100 PIV	35 AMP	1.70
IN4001	50 PIV	1 AMP	12/1.00	IN1186	200 PIV	35 AMP	1.80
IN4002	100 PIV	1 AMP	12/1.00	IN1188	400 PIV	35 AMP	3.00

TRANSISTORS

MPS A05	5 $1.00			PN4249	4 $1.00
MPS A06	5 $1.00	PN3567	3 $1.00	PN4250	4 $1.00
2N2219A	3 $1.00	PN3568	4 $1.00	2N4400	4 $1.00
2N2221	4 $1.00	PN3569	4 $1.00	2N4401	4 $1.00
2N2222A	5 $1.00	2N3704	5 $1.00	2N4402	4 $1.00
2N2369	5 $1.00	2N3705	5 $1.00	2N4403	4 $1.00
2N2369A	4 $1.00	2N3706	5 $1.00	2N4409	5 $1.00
FN2415	5 $1.00	2N3707	5 $1.00	2N5086	4 $1.00
2N2484	4 $1.00	2N3711	5 $1.00	2N5087	4 $1.00
2N2906A	4 $1.00	2N3724	$ .65	2N5088	4 $1.00
2N2907A	5 $1.00	2N3725	$1.00	2N5089	4 $1.00
2N2925	5 $1.00	2N3903	5 $1.00	2N5129	5 $1.00
2N3053	2 $1.00	2N3904	4 $1.00	2N5138	5 $1.00
2N3055	$ .89	2N3905	4 $1.00	2N5139	5 $1.00
MJE3055	$1.00	2N3906	4 $1.00	2N5209	5 $1.00
MJE2955	$1.25	2N4013	3 $1.00	2N5951	5 $1.00
2N3392	5 $1.00	2N4014	3 $1.00	C106B1SCR	2 $1.00
2N3398	5 $1.00			2N5432	$2.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10pf	05	04	03	001	05	04	035
22 pf	05	04	03	0047	05	04	035
47 pf	05	04	03	01	05	04	035
100 pf	05	04	03	022	06	05	04
220 pf	05	04	03	047	06	05	04
470 pf	05	04	035	1	12	09	075

100 VOLT MYLAR FILM CAPACITORS

001mf	12	10	07	022mf	13	11	08
0022	12	10	07	047mf	21	17	13
0047mf	12	10	07	1mf	27	23	17
01mf	12	10	07	22mf	33	27	22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

1	35V	28	23	17	1.5	35V	30	26	21
15	35V	28	23	17	2.2	25V	31	27	22
22	35V	28	23	17	3.3	25V	31	27	22
33	35V	28	23	17	4.7	25V	32	28	23
47	35V	28	23	17	6.8	25V	36	31	25
68	35V	28	23	17	10	25V	40	35	29
1.0	35V	28	23	17	15	25V	63	50	40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

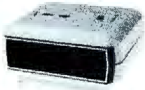
Axial Lead					Radial Lead				
47	50	15	13	10	47	25	15	13	10
1	50	16	14	11	47	50	16	14	11
3.3	50	15	13	10	1	16	15	13	10
4.7	25	16	14	12	1	25	16	14	11
10	25	15	13	10	1	50	16	14	11
10	50	16	14	12	4.7	16	15	13	10
22	25	17	15	12	4.7	25	15	13	10
22	50	24	20	18	4.7	50	16	14	11
47	25	19	17	15	10	16	14	12	09
47	50	25	21	19	10	25	15	13	10
100	25	24	20	18	10	50	16	14	12
100	50	35	30	28	47	50	24	21	19
220	25	32	28	25	100	16	19	15	14
220	50	45	41	38	100	25	24	20	18
470	25	33	29	27	100	50	35	30	28
1000	16	55	50	45	220	16	23	17	14
2200	16	70	62	55	470	25	31	28	26

CRYSTALS

Part #	Frequency	Case Style	Price
CY1A	1.000 MHz	HC33/U	$4.95
CY2A	2.000 MHz	HC33/U	$4.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

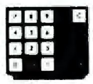
— AVAILABLE IN THESE FREQUENCIES ONLY —

CLOCK CASES



Nicely styled cases complete with red bezel for use in such applications as desk clocks, car clocks, alarm clocks, instrument cases.
DIMENSIONS: W-4", L-4½", H-2"
$5.95

MULTIPURPOSE KEYBOARDS



MULTIPURPOSE KEYBOARDS
20 Keys — Touch Tone
No schematic needed. Calculator use or re-arrange (pop-off) key tops. For touch tone or any control application. This unit may be cut apart for smaller units. **$2.95**

This unit was originally intended for calculator type applications but can be applied to a variety of other types of units, such as microcomputer interface, digital channel controlling, digital input to a frequency synthesizer, and even touch tone applications. The unit is composed of 18 very low bounce keys of the SPST type, and oneSPST slide switch. Numbers are white. Clear and Decimal are blue and all other keys are orange on a black background. **$2.49**

CALCULATOR CHIPS AND DRIVERS

MM5725	8 DIGIT 4 FUNCTION	$1.98
DM75491	SEGMENT DRIVER	.79
MM5736	6 DIGIT 4 FUNCTION	1.95
DM75492	DRIVER FOR 5736	.89
MM5738	8 DIGIT 5 FUNCTION	2.95
DM8864	DRIVER TYPE 1	2.00
DM8865	DRIVER TYPE 2	1.00

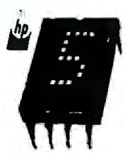
CLOCK CHIPS

MM5311	6 DIGIT W/BCD	$4.95
MM5312	4 DIGIT W/BCD	4.95
MM5313	6 DIGIT W/BCD	4.95
MM5314	6 DIGIT CLOCK	3.95
MM5316	ALARM CLOCK	4.95
CT7001	CAL/CLOCK CHIP	5.95

DIGITAL WATCH READOUT

FOR USE WITH WATCHES, DVMS, COUNTERS, ETC. $1.95

HP-5082-7300



HP 5082-7300
.3" Dot Matrix type numeric readouts with decoder/driver/latch built on the chip. Only 8 bins (BCD in, DP Latch, +5v, ground).
HP 5082 7300 **$5.95**

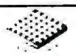
HP 5082 7304
+1 version of 7300 **4.95**

1¼"x 1½" XFMERS P.C. Mount

That were designed for clock type applications. 110 Vac primary @ 60 Hz.
Secondaries: 8-10 Vac @ 30 mA-50 mA
50 Vac @ 30 mA-50 mA
Excellent for miniature power supplies & gas discharge displays

SPECIAL $.79

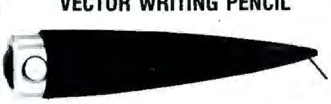
1/16 VECTOR BOARD



0.1" Hole Spacing P-Pattern

	Part No.	Length	Wideth	Price 1-19	Price 20-49
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 02XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

VECTOR WRITING PENCIL



Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin, onto component leads or terminals installed on pre-punched "P" Pattern Vectorbord®. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire. **$9.50 ea.**

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg. 3	(Green)	$2.40
W36-3-B-Pkg. 3	(Red)	$2.40
W36-3-C-Pkg. 3	(Clear)	$2.40
W36-3-D-Pkg. 3	(Blue)	$2.40

9V BATTERY CLIP

STANDARD CLIP FOR USE WITH 9V TRANSISTOR BATTERIES WITH 4" LEADS **9/.99**

TERMINAL STRIPS

THREE TERMINAL STRIPS, WITH CENTER TERMINAL USED FOR MOUNTING **15/$1.00**

AMP TERMINAL PINS

TERMINAL PINS FOR MOUNTING COMPONENTS ALSO PERFECT FOR USE WITH BOARD CONNECTORS AND SUBASSEMBLIES **$1.00/100 PCS.**

MICROPROCESSOR COMPONENTS

8080A $39.95

8080 AND 8008 SUPPORT COMPONENTS

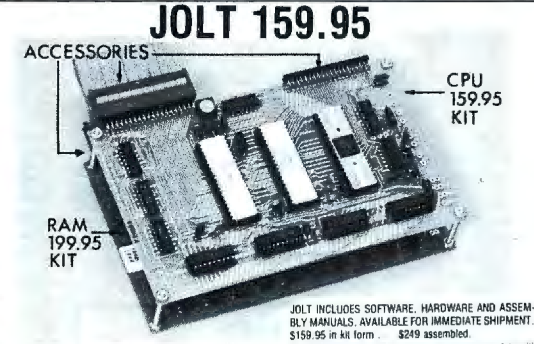
8224 CLOCK GENERATOR USED TO GENERATE TWO PHASE CLOCK NEEDED BY THE 8080 **$12.95**

74LS138 DECODER PERFECT FOR DECODING THE THREE 8008 STATE LINES INTO 8 USEABLE LINES FOR ADDRESS LATCHING **$3.98**

8228 SYSTEM CONTROLLER GENERATES A SYSTEM DATA BUS AND CONTROL SIGNALS FOR MEMORY **$21.25**

	CPU'S			RAM'S		
8008	8 BIT CPU	$19.95	1101	256X1	STATIC	$2.25
8080	SUPER 8008	39.95	1103	1024X1	DYNAMIC	6.95
4040	4 BIT 8080	39.95	2101	256X1	STATIC	6.95
	SR'S		2102	1024X1	STATIC	2.95
2504	1024 DYNAMIC	$9.00	2107	4096X1	DYNAMIC	19.95
2518	HEX 32 BIT	7.00	2111	256X4	STATIC	7.95
2519	HEX 40 BIT	4.00	7010	1024X1	MNOS	29.95
2524	512 DYNAMIC	3.50	7489	16X4	STATIC	2.49
2525	1024 DYNAMIC	6.00	8101	256X4	STATIC	7.95
2527	DUAL 256 BIT	3.95	8111	256X4	STATIC	7.95
2529	DUAL 512 BIT	4.00	8599	16X4	STATIC	3.49
2532	QUAD 80 BIT	3.95	91L02	1024X1	STATIC	2.95
2533	1024 STATIC	7.95	74200	1024X1	STATIC	6.95
3341	FIFO	6.95	93410	256X1	STATIC	1.75
74LS670	16X4 REG.	3.95	5262	2048X1	DYNAMIC	2.95
	UART'S			PROMS		
AY-5-1013	20K BAUD	$6.95	1702A	2048	FAMOS	15.95
	ROM'S		5203	2048	FAMOS	14.95
2513	CHAR. GEN.	11.00	8223	32X8	BIPOLAR	3.00
7488	RANDOM BITS	3.50	74S287	1024	STATIC	7.95

JOLT 159.95



The JOLT system consists of a set of modular microcomputer boards which can be used singly or tied together to produce any desired microcomputer system configuration. The minimum system is one CPU board, which alone constitutes a viable computer system complete with central processor, I/O, interrupts, timer, read-write memory, and a complete software debug monitor in read-only-memory.

JOLT INCLUDES SOFTWARE, HARDWARE AND ASSEMBLY MANUALS. AVAILABLE FOR IMMEDIATE SHIPMENT. $159.95 in kit form. $249 assembled.

JOLT SYSTEM DESCRIPTION

JOLT RAM Card — Fully static 4,096 bytes of RAM with 1 microsecond access time and on-board decoding. Hardware and assembly manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $199.95 kit . . . $285 assembled.

JOLT Power Supply — Operates at +5, +12 and −10 voltages. Supports JOLT CPU, 4k bytes of RAM and JOLT I/O card — or, CPU and 8 I/O cards. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $99.95 kit. $145 assembled.

JOLT Accessory Bag — Contains enough hardware to connect one JOLT card to another. Such necessary items as flat cable, connectors, cord spaces, hardware, etc. AVAILABLE FOR IMMEDIATE SHIPMENT. $39.95.

JOLT I/O Card (Peripheral Interface Adapter) — 2 PIA LSI chips, 32 I/O lines, four interrupt lines, on-board decoding and standard TTL drive. Fully programmable. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $95.50 kit . . $140 assembled.

JOLT Universal Card — Same size (4¼" x 7"), same ion, factor as other JOLT cards. Completely blank, drilled to accept 14, 16, 24 or 40 pin sockets. Used for additional user memory or I/O control panels, TV interfaces, keyboards, LEDs, or other interface logic. AVAILABLE FOR IMMEDIATE SHIPMENT. $24.95

JOLT +5V Booster Option — Fits onto JOLT Power Supply card. Supports CPU, 16k bytes of RAM — or, CPU and 8k bytes RAM and 8 I/O cards — or, CPU and 4k bytes RAM and 16 I/O cards. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $24.95

64 KEY BOARD

These are high quality keyboards, which were originally made by Digital Equipment Corporation. Each keyboard has 64 keys which are brought out on unencoded pins. They utilize magnetic reed type switches, and are new in appearance. **$29.95**

HD0165 Keyboard Encoder ROM **$7.95**

WIRE WRAP WIRE

AWG	COLOR	25 FT. MIN.	50 FT.	100 FT.	1000 FT.
30 AWG	WHITE	$2.10	$2.75	$3.50	$24.00
30 AWG	YELLOW	2.10	2.75	3.50	24.00
30 AWG	RED	2.10	2.75	3.50	24.00
30 AWG	GREEN	2.10	2.75	3.50	24.00
30 AWG	BLUE	2.10	2.75	3.50	24.00
30 AWG	BLACK	2.10	2.75	3.50	24.00

RIBBON CABLE

Conductors	1-9ft/ft	10-24ft/ft	25-99ft/ft	100ft
10	.39	.29	.25	.23
20	.59	.49	.45	.43
30	.79	.69	.65	.62
40	.99	.89	.85	.80
50	1.19	1.09	1.05	1.00

6' 2 CONDUCTOR POWER CORDS 125V @ 5A

3/1$

THREE CONDUCTOR POWER SUPPLY COROS

NUMBER	LENGTH	AWG	O.D.	RATING	COLOH	PRICE
17236	6	18(41X34)	.265	1250W 10A-125V	BLACK	Special .99 ea.
17237	6	18(41X35)	.253	1250W 10A-125V	GREY	1.25
17238	8	18(41X34)	.265	1250W 10A-125V	BLACK	Special .99 ea.
17239	8	18(41X34)	.253	1250W 10A-125V	GREY	1.30
17000	4	18(41X34)	.253	1250W 10A-125V	BLACK	.59

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax
Write for FREE 1976 Catalog — Data Sheets .25¢ each

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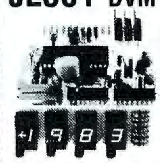
PHONE ORDERS — (415) 592-8097

JE SERIES KITS

JE801 DVM



The JE801 is a three and one half digit, auto polarity digital voltmeter, in a kit form. It features several options not available in any commercial digital voltmeter. Its low cost is perhaps the most important feature, which is achieved by offering it in a kit form. A kit allows the unit to be used by small OEM's where cost effectiveness is an important factor, and by the hobbyist who has to be concerned with cost. The unit also features on card regulators, allowing it to be operated off a single plus and minus fifteen volt, unregulated power supply. The unit has a small size of three inches width, three and three quarters of an inch length, and one and a quarter inch height.

$39.95 Per Kit printed circuit board

JE803 PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families. TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols (H) - 1 (LOW) - o (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

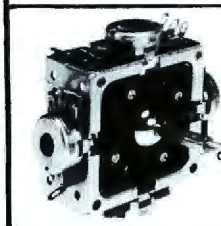
$7.95 Per Kit SPECIAL
printed circuit board

JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip. **$19.95**

12 or 24 Hour
115 VAC—
$19.95 per kit.

JOYSTICK



These joysticks feature four 100K potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

$9.95 ea

ELECTRONIC ROULETTE

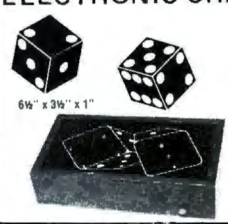
Complete kit with all components case and transformer.

$29.95 Per Kit

115 VAC

6½ x 6½ x 1½

ELECTRONIC CRAPS



6½" x 3½" x 1"

Complete kit with all components case and transformer.

$19.95 Per Kit

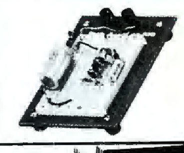
CONTINENTAL SPECIALTIES $15.95

PROTO BOARD 6

The PB-6 lets the user test and build circuits without soldering or patch cords: all interconnections between components are made with common #22 AWG hook-up wire. This quality breadboarding kit intudes 630 component tie points at less than 2.5c each. It measures 6" long by 4" wide. Designed specially to Breadboard Microprocessor Circuits. **$15.95**

PROTO BOARD 100

A low cost, big 10 IC capacity breadboard kit with all the quality of QT sockets and the best of the Proto Board series . . . complete down to the last nut, bolt and screw. Includes 2 QT-35S Sockets, 1 DT-35B Bus Strip, 2 5-way binding posts, 4 rubber feet, screws, nuts, bolts, and easy assembly instructions.
$19.95



Bring IC leads from pc board for fast signal tracing and troubleshooting. Inject signals. Wire unused circuits into boards. Scope probes and test leads lock onto Dynagrip inset (see circle) for hands-off testing. Plastic construction eliminates springs, pivots. Non-corrosive nickel/silver contacts for simultaneous low resistance connections.
PC-14, 14-pin Proto Clip, **$4.50 ea.**
PC-16, 16-pin Proto Clip, **$4.75 ea.**
PC-24, 24-pin Proto Clips, **$8.50 ea.**

CIRCLE NO. 28 ON FREE INFORMATION CARD

BINAURAL SOUND...

a remarkable listening experience for stereo headphone owners!

Created specifically for playback through stereo headphones, this unique record presents the listener with sound of unsurpassed realism. It recreates at each of the listener's ears the precise sound that each ear would have heard — independently — at the original scene.

Binaural recording re-creates the directions, distances, and even the elevations of sounds better than any other recording method. The super-realism of binaural recording is accomplished by recording the acoustical input for each ear separately, and then playing it back through stereo headphones. Thus the sound intended for the left ear cannot mix with the sound for the right ear, and vice versa.

Binaural recording offers the listener the identical acoustical perspective and instrument spread of the original. The sound reaching **each ear** is exactly the same as would have been heard at the live scene.

"MAX"— GENIE OF BINAURAL RECORDING. "Max," is a specially constructed dummy head, cast in silicone rubber, which duplicates the role of the human head as an acoustical absorber and reflector of sound. Super-precision capacitor microphones were installed in Max's ears so that each microphone would pick up exactly what each human ear would hear. The result is a demonstration of phenomenal recorded sound.

STARTLING REALITY. The Binaural Demonstration Record offers 45 minutes of sound and music of startling reality.

You'll marvel at the eerie accuracy with which direction and elevation are re-created as you embark on a street tour in binaural sound—Sounds Of The City . . . Trains, Planes & Ships . . . a Basketball Game, a Street Parade, a Steel Fabrication Plant, The Bird House at the Zoo—all demonstrating the incredible realism of binaural sound reproduction.

MUSIC IN BINAURAL. The musical performances presented on the Binaural Demonstration Record transport you to the concert hall for a demonstration of a wide variety of music. Selections total 23 minutes, and include examples of jazz, rock, organ, and chamber music.

The Stereo Review Binaural Demonstration Record is the ultimate in sound reproduction. It has been made without compromise for the owner of stereo headphones. If you own stereo headphones, this record is a **must**.

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☐ Enclosed is $________. (Residents of Calif., Col., Fla., Ill., Mich., Mo., N.Y. State, D.C. and Tex. add applicable sales tax.)

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FREE CATALOG. Ultrasonic Devices, LEDs, Transistors, IC's, Keyboards, Digital Thermometers, Unique Components. Chaney's, Box 15431, Lakewood, Colo. 80215.

SEMICONDUCTOR AND PARTS Catalogue from the semiconductor specialists. J & J Electronics, Box 1437, Winnipeg, Manitoba, Canada. U.S. Inquiries.

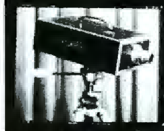
ELECTRONIC ignition: Pointless, Transistor, Capacitor. Vapor inductors, Auburn Sparkplugs. Information 10 cents. Anderson Engineering, Epsom, N.H. 03234.

TV PING PONG game. Plays through your set's antenna terminals: Plans $3.25. ARS SYSTEMS, Box 1922, Sunnyvale, CA 94088.

6 MHZ CRYSTALS including schematic and info to generate 60 hz-12VAC to make your digital clock run on batteries. $10.50 pp in US. Eastern Sales, Box 510, Raleigh, N.C. 27602.

FREE CATALOG. Kits and components. ELS Electronics, Box 581, Westbury, N.Y. 11590.

BUILD YOUR OWN TV CAMERA!
— Ideal for home & business —



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UNIVERSAL TTL/DTL/CMOS IC TESTER. Set Programming Switches, Plug In; Press To Test; Errors Displayed. Tests 16/14 pin ICs! Easy Circuit Construction with TTL. Illustrated Info/Plans: $2.00; NORTHSTAR ENGINEERING, 3617 North Crede Drive, Charleston, WV 25302.

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Our VIDEO board has the ability to display GRAPHICS as well as text. **Graphics and text can even be displayed together on the same screen—great for games and displays**—FEATURES:

- 16 lines of 32 characters on a standard TV monitor or modified TV (expandable to 64 characters with optional memory for use with high resolution monitors)
- 128 characters (7 x 9 font) incl. upper and lower case
- 48 x 64 dot matrix for graphics (48 x 128 with memory option)
- The display may be written or read in less than 20msec
- 8 bit keyboard input port provided on board
- Complete curser, text editing and plotting software incl

PRICES: $160 kit, $230 assem, memory option $25

Interface your computer to the analog world with our A/D D/A interface board—FEATURING:

- 1 or 2 analog outputs with 10 bit resolution
- 8 Analog inputs—software controlled A/D conversion
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- 6 Digital outputs for control functions
- Use for CRT graphics display plots up to 20K lines/sec

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Both boards are fully Altair 8800 plug compatible. Each is on a single double-sided board with plated through holes and gold plated contacts. Application notes, assembly instructions (kit version), and software is included with each board.

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POLYMORPHIC SYSTEMS
P. O. Box 2207 Goleta, CA 93018
MASTERCHARGE ACCEPTED

COMPUTER, 8 bit serial, complete, $225. Scope display generator, 128 characters, parallel input, $85. Brochure 10 cents. RAECO, Box 14, Readville, Mass. 02137.

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UNBEATABLE—2N5296 NPN 36W audio power transistor 3/$1.00. MPSA70 PNP general purpose 10/$1.00. 200/16V axial capacitor 7/$1.00. $.50 handling. Winebrenner, 612 S. Ijams, Garrett, IN 46738.

ALTAIR 8800 assembled and tested $450 ppd. E. Wong, 1027 West 34th Street, Los Angeles, Calif. 90007.

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SPECIAL! Pin Photo Detector HP5082-4203 ... $1.99. Catalog Electronic Parts. BDJ Electronics, 33 Howard, Orangeburg, New York 10962.

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AMAZING cordless electric lawnmower. FREE information. No waiting plans $10.00. Amonics, P.O. Box 1045, Norman, Oklahoma 73069.

MEMORY SYP21LO2A Synertek 1K Static Rams $2.75, 4.5" x 6.5" 4K card. Inquire: Wm. Witherspoon, 3558 Stony Point Road, Grand Island, N.Y. 14072.

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Slashes time of point-to-point wiring! 36 gauge wire has special insulation that melts when heated. Reviewed in Dec 75 PE. With 1 red, 1 green wire bobbin & instructions. +1 lb shp.

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OK, all you wire pencil fanatics, here's replacement wire: 3 bobbins/$2.40. Specify RED, GREEN, BLUE, or CLEAR.

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12 VOLTS, 8A!

Remember the 12V, 6A supply in the Dec 74 Popular Electronics? This IMPROVED version offers an 8 amp continuous rating, adjustable output 11-14V, total short circuit protection, and much more. For powering mobile equipment, tape players, bench supply, or whatever. Kit complete, but less chassis and hardware...$22.50 plus shipping for 7 pounds.

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This kit provides dual tracking, regulated voltages from ±1V to over ±18V, at up to 200 ma per side. Short circuit protected, thermal limiting. Kit (less case & hardware) $10.95 + 2 lbs shipping.

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5370 $4.50
THE SECOND GENERATION ALARM CLOCK IC: Multiplexed digits make it much easier to apply than the 5316. Hrs + mins, snooze, alarm out, more.

2102 $1.95
THE SPECIAL CONTINUES with our guaranteed under 750 ns. 2102s; qty discounts, too...

5203 $9.95
2K EROM; erases with UV light. Programable and versatile memory.

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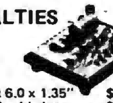


PROTO BOARDS

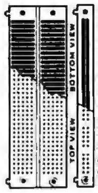
Build & test circuits as fast as you think!

PB100	10 IC cap breadboard kit, 4.5 x 6.0 x 1.35"	$19.95
PB101	10 14-DIP cap, 5-way post, 940 solderless tie points, 5.8 x 4.5"	$29.95
PB102	12 14-DIP cap., like PB101 with 1,240 tie points, 7.0 x 4.5"	$39.95
PB103	24 14-DIP cap., 4 5-way posts, 2,250 tie points, 6.0 x 9.0"	$59.95
PB104	32 14-DIP cap., 3060 solderless tie points, 8.0 x 9.76"	$79.95

LOGIC MONITOR
Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs. Pocket size. $84.95.

PRDTO-CLIP
For power-on/hands-off signal tracing. Bring IC leads up from PC board surface for fast trouble-shooting.

PC14	14-pin	$4.50
PC16	16-pin	4.75



SOCKETS & BUS STRIPS

Plug-in, wire, test, modify or expand without patch cords or solder. Snap together to form breadboard needed.

PN/Description	L.	Hole-to-Hole	Term'ls	Price
QT59S Socket	6.5"	6.2"	118	$12.50
QT59B Bus	6.5"	6.2"	20	2.50
QT47S Socket	5.3"	5.0"	94	10.00
QT47B Bus	5.3"	5.0"	16	2.25
QT35S Socket	4.1"	3.8"	70	8.50
QT35B Bus	4.1"	3.8"	12	2.00
QT18S Socket	2.4"	2.1"	35	4.75
QT12S Socket	1.8"	1.5"	24	3.75
QT8S Socket	1.4"	1.1"	16	3.25
QT7S Socket	1.3::	1.0"	14	3.00

LINEAR IC's

H=TO-5 N=DIP M=MINI-DIP D=CER-DIP K=TO-3

LM105H	3.90	LM311H	1.20	LM710CH	.90
LM108H	4.90	LM311D	.90	LM710CN	.90
LM114H	3.00	LM311M	1.75	LM711CH	.90
LM300H	1.20	LM312N	1.75	LM711CN	.90
LM300N	1.20	LM318H	1.50	LM715CH	3.50
LM301AH	.50	LM318M	2.40	LM715CD	4.60
LM301AM	.80	LM324N	1.90	LM723CH	.60
LM301AN	1.10	LM331N	1.25	LM723CN	.65
LM301M	.95	LM336K	2.40	LM725CH	1.50
LM302N	1.30	LM339N	2.20	LM725CD	5.00
LM302H	1.40	LM320-5K	2.90	LM733CH	1.40
LM304H	1.20	LM320-5T	2.50	LM733CD	3.50
LM305H	.85	LM320-12K	2.90	LM733CN	1.30
LM305AH	1.05	LM320-12T	2.50	LM741CH	.40
LM305N	1.00	LM340-5K	2.60	LM741CD	1.25
LM306N	.95	LM340-6K	2.60	LM741CM	.39
LM307H	.60	LM340-8K	2.60	LM747CH	.75
LM307M	1.50	LM340-12K	2.60	LM747CN	.90
LM308H	.85	LM340-15K	2.60	LM748CM	.55
LM308AH	5.00	LM340-18K	2.60	LM777CH	2.15
LM308D	2.25	LM340-24K	2.60	LM777CM	2.10
LM308M	1.00	LM555CM	.70	LM3046CN	.95
LM309H	1.75	LM556CM	1.30	LM3054CN	1.50
LM309K	1.50	LM567CM	1.70	SG4501T	2.40
LM310H	1.50	LM709CH	.75	SG4501N	2.40
LM310M	1.80	LM709CN	.75	LM5000K	7.50

MICROPROCESSORS

	1-9	10 up
8080	59.00	39.90
P1101A	2.20	2.10
P1101A1	3.50	3.30
P2102-1	3.90	3.00
91L02	3.90	3.20
91L02-1	3.90	3.20

1702	17.00
P8101	5.50
P8101-2	6.00
P8102	4.00
P8102-2	4.00
P8111	5.60
P8111-2	6.00
9102PC	4.00

COMPUTER INTERFACE

DM8820N	2.40
DM8820AN	6.90
DM8830N	2.40
DM8831N	5.20
DM8832N	6.00
N8T26B	4.40
9600PC	1.30
9601PC	1.20
9602PC	1.95
9614PC	2.30
9615PC	2.40
9616PC	5.00
9617PC	3.50
9620PC	4.00
9621PC	4.00

75107

75107BN	2.60
75108BN	2.30
75109N	2.20
75110N	2.20
75115N	2.25
75138N	2.95
75150N	3.10
75154N	4.10
75208N	2.70
75234N	2.50
75450N	1.25
75451N	1.00
75452N	1.00
75453N	1.00

7520 SERIES SENSE AMPS

7520N	4.00
7521N	2.00
7522N	4.25
7523N	1.75
7524N	2.00
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TWO-PHASE MOS CLOCK DRIVER

MH0026CN 5.50

DECODED READ/WRITE RAM

P1103 5.90

2524V Recirculating 512 Bit Dynamic Shift Register

1-24	2.40
25 up	2.30

BIPOLAR MEMORY

C3101	6.50
P3101	4.90
C3101A	7.30
P3101A	5.80
IM5501CDE	7.30
IM5501CPE	5.80
MM5560D	7.30
MM5560N	5.80
DM8599N	5.80
93403PC	5.80

1024-BIT N-Channel RAM

C2102	5.00
P-2102	2.85
C2102-1	5.00
P-2102-1	3.90
C2102-2	6.00
P-2102-2	3.00
P-2102A	8.00
P-2102A-2	9.50
P-2102A-4	6.00
2601-1	4.00
2601-21	11.40
2602B	3.80
2602-1B	4.40
2602-2B	4.00
MK4102P	11.40
7552-1CPE	6.00
7552-2CPE	6.00
TMS4033JL	9.00
TMS4033NL	4.20
TMS4034JL	9.00
TMS4034NL	4.20
TMS4035JL	9.00
TMS4035NL	4.20

MM

MM404H	12.00
MM405H	23.00
MM406H	6.50
MM407H	6.50
MM451H	11.40
MM454F	18.00
MM500H	2.00
MM506H	3.20
MM507H	3.20
MM550H	5.90
MM551H	5.60
MM555H	5.60

MOS-LSI

1402AN	3.80
1403AH	4.00
1403AN	3.80
1404AH	4.50
1404AN	2.90
1405A	4.00
1406	8.40
1407	8.40
1506	3.00
1507	3.00
1602	33.00
P2101	5.00
P2101-1	5.50
P2101-2	4.90
P2111	5.80
P2111-1	6.00
P2111-2	5.90
P2112	5.00
P2112-2	5.90
P2401	9.90
P2405	9.70
2505K	3.30
2512K	4.00
2521V	2.50
2525V	3.50
2533V	7.90
2803PC	4.00
2804PC	4.00
2807PC	2.70
2808PC	4.00
TMS3114J	9.40
TMS3120JC	7.00
TMS3120NC	6.00
TMS3133NC	7.50
3341ADC	8.00
3341APC	7.00
3347DC	5.80
3347PC	4.60
4102	4.95
7552	4.95
7552-1	5.40
7552-2	5.50
MM4055D	12.00
MM4056H	9.70
MM4057D	13.00
MM5025N	20.00
MM5026N	20.00
MM5027N	20.00
MM5055N	5.60
MM5056N	5.50
MM5057N	5.50
MM5058N	6.50

7400N TTL

7400N	$.12	7442N	.58	7497N	5.00	74164N	1.10
7401N	.16	7443N	.74	74100N	1.00	74165N	1.10
7402N	.14	7444N	.73	74104N	1.20	74166N	1.28
7403N	.16	7445N	.75	74105N	.50	74170N	1.97
7404N	.19	7446N	.76	74107N	.33	74173N	1.29
7405N	.19	7447N	.72	74109N	.74	74174N	1.14
7406N	.29	7448N	.80	74110N	.72	74176N	.98
7407N	.29	7450N	.14	74111N	1.20	74176N	1.25
7408N	.18	7451N	.14	74116N	2.00	74177N	1.40
7409N	.20	7453N	.14	74121N	.36	74178N	1.42
7410N	.18	7454N	.14	74122N	.38	74179N	3.60
7411N	.26	7459N	.20	74123N	.71	74180N	.75
7412N	.33	7460N	.14	74125N	.46	74181N	2.39
7413N	.44	7470N	.26	74126N	.63	74182N	.67
7414N	1.05	7472N	.26	74128N	.84	74184N	1.84
7416N	.28	7473N	.37	74132N	1.10	74185N	2.20
7417N	.33	7474N	.32	74136N	.96	74188N	4.75
7418N	.30	7476N	.50	74141N	1.20	74190N	1.17
7420N	.13	7476N	.32	74145N	.89	74191N	1.17
7421N	.33	7480N	.59	74147N	2.40	74192N	1.08
7422N	.60	7481N	1.30	74148N	2.00	74193N	1.02
7423N	.48	7482N	.89	74150N	1.00	74194N	1.05
7425N	.23	7483N	.66	74151N	.80	74195N	.74
7426N	.22	7484N	3.00	74152N	1.40	74196N	.99
7427N	.25	7485N	.90	74153N	.79	74197N	.76
7428N	.33	7486N	.34	74154N	1.40	74198N	1.51
7430N	.20	7489N	2.12	74155N	1.00	74199N	1.50
7432N	.24	7490N	.48	74156N	.78	74200N	5.60
7433N	.36	7491N	.78	74157N	.69	74221N	1.50
7437N	.29	7492N	.49	74158N	1.52	74251N	1.40
7438N	.29	7493N	.49	74160N	.98	74278N	2.45
7439N	.38	7494N	.72	74161N	.99	74279N	.94
7440N	.16	7495N	.80	74162N	.99	74293N	1.00
7441N	.83	7496N	.67	74163N	.99	74298N	1.98

HIGH SPEED TTL

74H00N	.33	74H20N	.33	74H52N	.36	74H73N	.80
74H01N	.25	74H21N	.33	74H53N	.36	74H74N	.80
74H04N	.33	74H22N	.33	74H54N	.36	74H76N	.75
74H05N	.33	74H30N	.33	74H55N	.36	74H102N	.75
74H08N	.40	74H40N	.36	74H60N	.36	74H103N	.90
74H10N	.33	74H50N	.36	74H71N	.75	74H106N	.95
74H11N	.33	74H51N	.38	74H72N	.75		

LOW POWER TTL

74L00N	.24	74L10N	.24	74L51N	.34	74L90N	1.62
74L02N	.24	74L20N	.33	74L73N	.48	74L93N	1.74
74L03N	.39	74L42N	1.49	74L74N	.90	74L95N	1.62
74L04N	.33						

74LS

74LS00	.42	74LS27	.47	74LS112	.65	74LS170	5.80
74LS01	.58	74LS30	.42	74LS113	.92	74LS174	2.25
74LS02	.42	74LS32	.47	74LS114	.92	74LS175	2.42
74LS03	.50	74LS38	.53	74LS138	1.94	74LS181	7.00
74LS04	.47	74LS51	.50	74LS139	2.06	74LS194	2.40
74LS08	.42	74LS54	.48	74LS151	1.92	74LS195A	2.40
74LS09	.58	74LS55	.58	74LS153	1.92	74LS196	2.76
74LS10	.42	74LS73	.65	74LS157	1.68	74LS251	2.06
74LS11	.42	74LS74	.65	74LS158	1.68	74LS253	2.42
74LS15	.58	74LS76	.92	74LS160	3.06	74LS257	2.06
74LS20	.42	74LS78	.92	74LS161	3.06	74LS258	2.06
74LS21	.58	74LS107	.92	74LS162	3.06	74LS260	.58
74LS22	.58	74LS109	.92	74LS163	2.90		

SCHOTTKY TTL

74S00	.44	74S32	.80	74S113	1.50	74S174	3.30
74S01	.76	74S40	.65	74S114	1.20	74S175	2.90
74S02	.60	74S50	.76	74S133	.80	74S181	6.00
74S03	.75	74S51	.80	74S138	2.20	74S189	4.40
74S04	.55	74S60	.80	74S139	2.20	74S194	3.30
74S05	.76	74S64	.80	74S140	.80	74S195	3.30
74S08	.80	74S65	.80	74S151	2.20	74S251	2.20
74S09	.76	74S74	.90	74S153	3.40	74S253	2.40
74S10	.55	74S76	1.15	74S157	2.40	74S257	2.40
74S11	.65	74S78	1.16	74S158	2.00	74S258	2.40
74S15	.76	74S85	5.10	74S160	3.90	74S260	1.20
74S20	.65	74S86	2.50	74S161	4.70	74S280	5.70
74S21	.76	74S112	1.00	74S172	6.00	74S289	4.00
74S30	.80						

9300 SERIES

9300PC	$1.00	9318PC	2.30	9366PC	1.75	93L18	3.50
9301PC	1.20	9321PC	1.20	93L00	1.50	93L21	1.50
9304PC	1.50	9322PC	1.30	93L01	1.60	93L22	1.80
9306PC	6.90	9324PC	2.00	93L08	3.20	93L24	2.80
9308PC	2.50	9328PC	2.50	93L09	1.80	93L28	3.70
9309PC	1.60	9334PC	2.95	93L10	2.80	93L34	4.00
9310PC	1.50	9338PC	3.30	93L11	4.20	93L38	4.20
9311PC	2.30	9340PC	5.00	93L12	1.80	93L40	6.50
9312PC	1.20	9341PC	4.10	93L14	1.70	93L41	6.50
9314PC	1.30	9342PC	1.15	93L16	3.20	93L60	3.00
9316PC	1.50	9360PC	1.75	93L18	3.50	93L66	2.70

C-MOS

P/N	1-9	10up	P/N	1-9	10up	P/N	1-9	10up
4000AE	.22	.21	4027AE	.50	.49	4070AE	.60	.59
4001AE	.23	.22	4028AE	.84	.83	4071AE	.22	.21
4002AE	.23	.22	4029AE	1.23	1.22	4072AE	.40	.39
4004AE	4.00	3.99	4030AE	.38	.37	4073AE	.33	.32
4006AE	1.16	1.15	4033AE	1.95	1.94	4075AE	.50	.49
4007AE	.22	.21	4035AE	1.08	1.07	4076AE	1.24	1.23
4008AE	1.79	1.78	4040AE	1.24	1.23	4077AE	.70	.69
4009AE	.60	.50	4041AE	1.82	1.81	4078AE	.50	.49
4010AE	.46	.45	4042AE	.78	.77	4081AE	.22	.21
4011AE	.24	.23	4043AE	.78	.77	4082AE	.50	.49
4012AE	.21	.20	4044AE	.78	.77	4095AE	2.00	1.99
4013AE	.38	.37	4047AE	2.75	2.74	4098AE	1.30	1.29
4014AE	1.24	1.23	4048AE	1.43	1.42	4099AE	2.90	2.89
4015AE	1.24	1.23	4049AE	.49	.48	4507AE	.60	.55
4016AE	.46	.45	4050AE	.49	.48	4508AE	2.20	2.19
4017AE	1.01	1.00	4051AE	1.49	1.48	4510AE	1.24	1.23
4018AE	1.24	1.23	4052AE	1.49	1.48	4514AE	5.00	4.99
4019AE	.49	.48	4053AE	1.49	1.48	4515AE	5.00	4.99
4020AE	1.24	1.23	4055AE	1.99	1.98	4516AE	1.75	1.74
4021AE	1.24	1.23	4056AE	1.99	1.98	4518AE	1.28	.98
4022AE	.94	.93	4060AE	1.98	1.97	4520AE	1.28	.98
4023AE	.23	.22	4063AE	2.50	2.49	4528AE	1.36	1.35
4024AE	.75	.74	4066AE	.76	.75	4585AE	1.78	1.77
4026AE	.23	.22	4068AE	.50	.49	4901AE	.43	.36
4026AE	1.90	1.89	4069AE	.35	.34	4911AE	.43	.36

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14	.25	.22	.20	16	.54	.49	.44
16	.26	.25	.23				
24	.67	.61	.65				
28	.88	.80	.72				
36	1.09	.98	.89				
40	1.24	1.12	.92				

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209	YELLOW	.35
209	GREEN	.35

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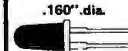

216	RED	$.25
216	YELLOW	.30
216	GREEN	.30

.200" dia.

220	RED	$.25
220	YELLOW	.30
220	GREEN	.30

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226	RED	$.25
226	YELLOW	.30
226	GREEN	.30
226	ORANGE	.30

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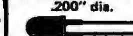

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		1-9	10 up
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APS15-3	15	3		
APS24-2.2	24	2.2		
APS28-2	28	2		
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APS15-6	15	6		
APS24-5	24	5		
APS28-4	28	4		

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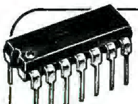

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7403	.21	7476	.32	74177	.79	4007	.23	4082	.23
7404	.21	7480	.70	74180	.70	4008	.79	4502	.79
7405	.21	7482	.70	74181	2.15	4009	.44	4510	1.14
7406	.25	7483	.70	74182	.79	4010	.44	4511	1.05
7407	.25	7485	.89	74184	2.19	4011	.23	4514	2.80
7408	.21	7486	.28	74185	2.19	4012	.23	4515	2.80
7409	.21	7489	2.19	74188	3.50	4013	.40	4516	1.23
7410	.21	7490	.44	74189	3.50	4014	.96	4518	1.14
7411	.21	7491	.70	74190	1.23	4015	.96	4520	1.14
7412	.21	7492	.44	74191	1.23	4016	.40	4527	1.68
7413	.25	7493	.44	74192	.88	4017	1.05	4528	.88
7414	.89	7494	.70	74193	.88	4018	1.05	4585	1.23
7416	.25	7495	.70	74194	.88	4019	.23	LM309K	1.80
7417	.25	7496	.70	74195	.88	4020	1.14	LM324N	1.28
7420	.21	74100	1.28	74196	.88	4021	1.14	LM340T-5	1.25
7421	.25	74107	.30	74197	.88	4022	.96	LM340T-6	1.25
7423	.35	74109	.33	74198	1.49	4023	.23	LM340T-8	1.25
7425	.35	74121	.35	74199	1.49	4024	.84	LM340T-12	1.25
7426	.25	74122	.44	74251	1.09	4025	.23	LM340T-15	1.25
7427	.33	74123	.61	74279	.58	4026	1.68	LM340T-18	1.25
7428	.28	74125	.40	74365	.67	4027	.40	LM340T-24	1.25
7430	.21	74126	.40	74366	.67	4028	.89	LM3900N	.88
7432	.25	74132	.70	74367	.67	4029	1.14	NE536T	3.24
7433	.30	74141	.88	74368	.67	4030	.23	NE540L	2.04
7437	.25	74145	.70	75150	1.31	4033	1.51	NE555V	.48
7438	.25	74147	1.63	75450	.88	4034	3.50	NE556A	.88
7440	.21	74148	1.30	75451	.61	4035	1.14	NE560B	3.83
7441	.88	74150	1.16	75452	.61	4040	1.14	NE561B	3.83
7442	.53	74151	.70	75453	.61	4041	.79	NE562B	3.83
7443	.63	74153	.65	75454	.61	4042	.79	NE565A	1.23
7444	.63	74154	1.03	75491	.81	4043	.70	NE566V	1.28
7445	.70	74155	.70	75492	.84	4044	.70	NE567V	1.36
7446	.70	74156	.70	75493	1.09	4046	1.86	uA709CV	.44
7447	.70	74157	.70	75494	1.19	4049	.40	uA710CA	.44
7448	.70	74160	.88	8093	.40	4050	.40	uA711CA	.53
7450	.21	74161	.88	8094	.40	4051	1.26	uA723CA	.60
7453	.21	74162	.88	8095	.67	4052	1.26	uA741CV	.44
7454	.21	74163	.88	8096	.67	4053	.72	uA747CA	.70
7460	.21	74164	.96	8097	.67	4060	1.58	uA748CV	.49
7470	.30	74166	1.26	8098	.67	4066	.79	MC1458V	.53
7472	.30	74170	2.64	82525	2.19	4071	.23	2102	2.65
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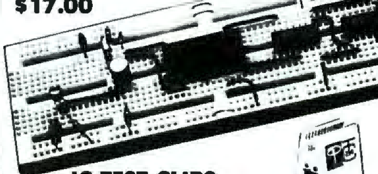

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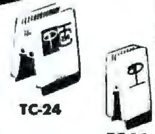

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ELECTROLYTIC CAPACITORS

— Radial Lead —

luf/50v	.08	.65/10
2.2uf/50v	.08	.65/10
3.3uf/50v	.08	.65/10
4.7uf/25v	.08	.65/10
4.7uf/50v	.08	.70/10
10uf/25v	.08	.65/10
10uf/50v	.10	.75/10
22uf/25v	.09	.70/10
22uf/50v	.12	1.00/10
100uf/6.3v	.09	.75/10
100uf/16v	.11	.85/10
100uf/25v	.13	1.10/10

— Axial Lead —

luf/50v	.11	.90/10
2.2uf/50v	.12	.90/10
3.3uf/35v	.12	.95/10
3.3uf/50v	.12	1.00/10
4.7uf/25v	.11	.90/10
4.7uf/35v	.12	.95/10
10uf/16v	.11	.90/10
10uf/25v	.12	1.00/10
10uf/50v	.14	1.15/10
22uf/16v	.12	1.00/10
22uf/25v	.13	1.05/10
33uf/16v	.12	1.00/10
33uf/25v	.14	1.15/10
47uf/16v	.14	1.15/10

— Axial Lead —

47uf/25v	.17	1.30/10
100uf/16v	.17	1.30/10
100uf/25v	.20	1.55/10
100uf/50v	.29	2.30/10
220uf/16v	.20	1.55/10
220uf/25v	.29	2.35/10
220uf/50v	.29	2.35/10
330uf/16v	.29	2.35/10
330uf/25v	.32	2.55/10
470uf/16v	.32	2.55/10
470uf/25v	.37	3.00/10
1000uf/16v	.39	3.15/10
1000uf/25v	.56	4.50/10
2200uf/16v	.62	4.95/10

DISC CAPS

100pf/500v	.04	.36/10
220pf/500v	.04	.36/10
470pf/500v	.04	.36/10
1000pf/500v	.04	.37/10
2200pf/500v	.04	.37/10
4700pf/500v	.04	.32/10
.01ufd/500v	.06	.50/10
.01ufd/50v	.03	.24/10
.022ufd/25v	.03	.28/10
.047ufd/25v	.05	.42/10
.1ufd/25v	.08	.62/10

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1N5227B	3.6v	.15	$11/C		1N5237B	8.2v	.15	$11/C
1N5228B	3.9v	.15	$11/C		1N5238B	8.7v	.15	$11/C
1N5229B	4.3v	.15	$11/C		1N5239B	9.1v	.15	$11/C
1N5230B	4.7v	.15	$11/C		1N5240B	10v	.15	$11/C
1N5231B	5.1v	.15	$11/C		1N5241B	11v	.15	$11/C
1N5232B	5.6v	.15	$11/C		1N5242B	12v	.15	$11/C
1N5233B	6.0v	.15	$11/C		1N5243B	13v	.15	$11/C
1N5234B	6.2v	.15	$11/C		1N5244B	14v	.15	$11/C
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28 Pin Solder Tab	.45
40 Pin Solder Tab	.63
8 Pin Wire-Wrap	.24
14 Pin Wire-Wrap	.26
16 Pin Wire-Wrap	.30
18 Pin Wire-Wrap	.60
24 Pin Wire-Wrap	.86
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8-32 3/8 Screw	.90/C	5.85/M
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4-40 Hext Nut	.55/C	3.75/M
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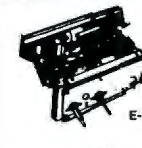

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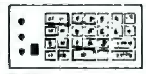

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•Touch tone type contacts • Complete on circuit board • Frame holds keys and 4 slide switches • 7 5/8"S x 3-11/16"D x 1 3/4" Highest point • 1 1/4" Lowest point. • Shipping wt 1 lb

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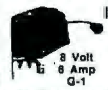

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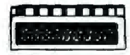

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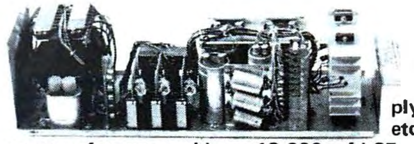

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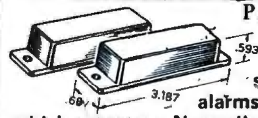

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2SA628	.65	2SB407	1.65	2SC537	.70	2SC1051	2.50	2SD88	1.50
2SA643	.85	2SB415	.85	2SC563	2.50	2SC1061	1.65	2SD151	2.25
2SA647	2.75	2SB461	1.25	2SC605	1.00	2SC1079	3.75	2SD170	2.00
2SA673	.85	2SB463	1.65	2SC620	.80	2SC1096	1.20	2SD180	2.75
2SA679	3.75	2SB471	1.75	2SC627	1.75	2SC1098	1.15	2SD201	1.95
2SA682	.85	2SB474	1.50	2SC642	3.50	2SC1115	2.75	2SD218	4.75
2SA699	1.30	2SB476	1.25	2SC643	3.75	2SC1166	.70	2SD300	2.50
2SA699A	1.75	2SB481	2.10	2SC644	.70	2SC1170	4.00	2SD313	1.10
2SA705	.55	2SB492	1.25	2SC681	2.50	2SC1172B	4.25	2SD315	.75
2SA815	.85	2SB495	.95	2SC684	2.10	2SC1209	.55	2SD318	.95
2SA816	.85	2SB507	.90	2SC687	2.50	2SC1213	.75	2SD341	.95
		2SB511	.70	2SC696	2.35	2SC1226	1.25	2SD350	3.25
2SB22	.65			2SC712	.70	2SC1243	1.50	2SD352	.80
2SB54	.70	2SC206	1.00	2SC713	.70	2SC1293	.85	2SD380	5.70
2SB56	.70	2SC240	1.10	2SC732	.70	2SC1308	4.75	2SD389	.90
2SB77	.70	2SC261	.65	2SC733	.70	2SC1347	.80	2SD-390	.75
2SB128	2.25	2SC291	.65	2SC739	.70	2SC1383	.75	2SD437	5.50
2SB135	.95	2SC320	2.00	2SC715	1.75	2SC1409	1.25		
2SB152	4.50	2SC352	.75	2SC762	1.90	2SC1410	1.25	C106B1	.50
2SB173	.55	2SC353	.75	2SC783	1.00	2SC1447	1.25		
2SB175	.55	2SC371	.70	2SC784	.70	2SC1448	1.25		
2SB178	1.00	2SC372	.70	2SC785	1.00	2SC1507	1.25		
2SB186	.60	2SC394	.70	2SC793	2.50	2SC1509	1.25		

POWER-TRANSISTORS HIGH-VOLT. TV. TYPE

BU204	1300V	3.90	BU207	1300V	5.40	2SC1172B	1100V	4.25
BU205	1500V	4.70	BU208	1500V	6.25	2SC308	1100V	4.95
BU206	1700V	5.90	2SC1170	1100V	4.00	2SC1325	1100V	4.95

OEM SPECIALS

1N270	.10	2N960	.55	2N2219A	.30	2N2913	.75	2N3740	1.00	2N4401	.20
1N914	.10	2N962	.40	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.20
		2N967	.50	2N2221A	.30	2N2916A	3.65	2N3732	1.90	2N4403	.20
2N173	1.75	2N1136	1.35	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.20
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.32	2N4410	.25
2N327A	1.15	2N1302	.25	2N2270	.40	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1305	.30	2N2322	1.00	2N3055	.75	2N3856	.20	2N4441	.85
2N336	.90	2N1377	.75	2N2323	1.00	2N3227	1.00	2N3866	.85	2N4442	.90
2N338A	1.05	2N1420	.20	2N2324	1.35	2N3247	3.40	2N3903	.20	2N4443	1.20
2N398B	.90	2N1483	.95	2N2325	2.00	2N3250	.50	2N3904	.20	2N4852	.55
2N404	.30	2N1540	.90	2N2326	2.85	2N3375	6.50	2N3905	.20	2N5061	.30
2N443	1.75	2N1543	2.70	2N2327	3.80	2N3393	.20	2N3906	.25	2N5064	.50
2N456	1.10	2N1544	.80	2N2328	4.20	2N3394	.17	2N3925	3.75	2N5130	.20
2N501A	3.00	2N1549	1.25	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5133	.15
2N508A	.45	2N1551	2.50	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5138	.15
2N555	.45	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5198	3.75
2N652A	.85	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5294	.50
2N677C	6.00	2N557	.15	2N2712	.18	2N3442	1.85	2N3958	1.20	2N5296	.50
2N706	.25	2N1560	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5306	.20
2N706B	.40	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5354	.20
2N711	.50	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.20	2N5369	.20
2N711B	.60	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.20	2N5400	.40
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	2N5401	.50
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.15	2N4142	.20	2N5457	.35
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.15	2N4143	.20	C103Y	.25
2N918	.35	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45	C103D	.40
2N930	.25	2N2218A	.30	2N2907	.25	2N3730	1.50	2N4234	.95	C106B1	.50
2N956	.30	2N2219	.25	2N2907A	.30	2N3731	2.75	2N4400	.20	C106D1	.75

SILICON UNIJUNCTIONS

2N2646	.50	2N2160	.65
2N2647	.60	2N4870	.50
2N6027	.55	2N4871	.50
2N6028	.70	2N4891	.50
D5E37	.25	2N4892	.50
		2N4893	.50
		2N4894	.50
		MU10	.40

INTEGRATED CIRC.

UA703C	.40
709C OP. AMP.	.25
741C OP. AMP.	.25
7400	.15
7404N	.18
7430N	.19
74L00J	.35
74H55N	.35

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IN4004	.90	8.00
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IN4006	1.10	10.00
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